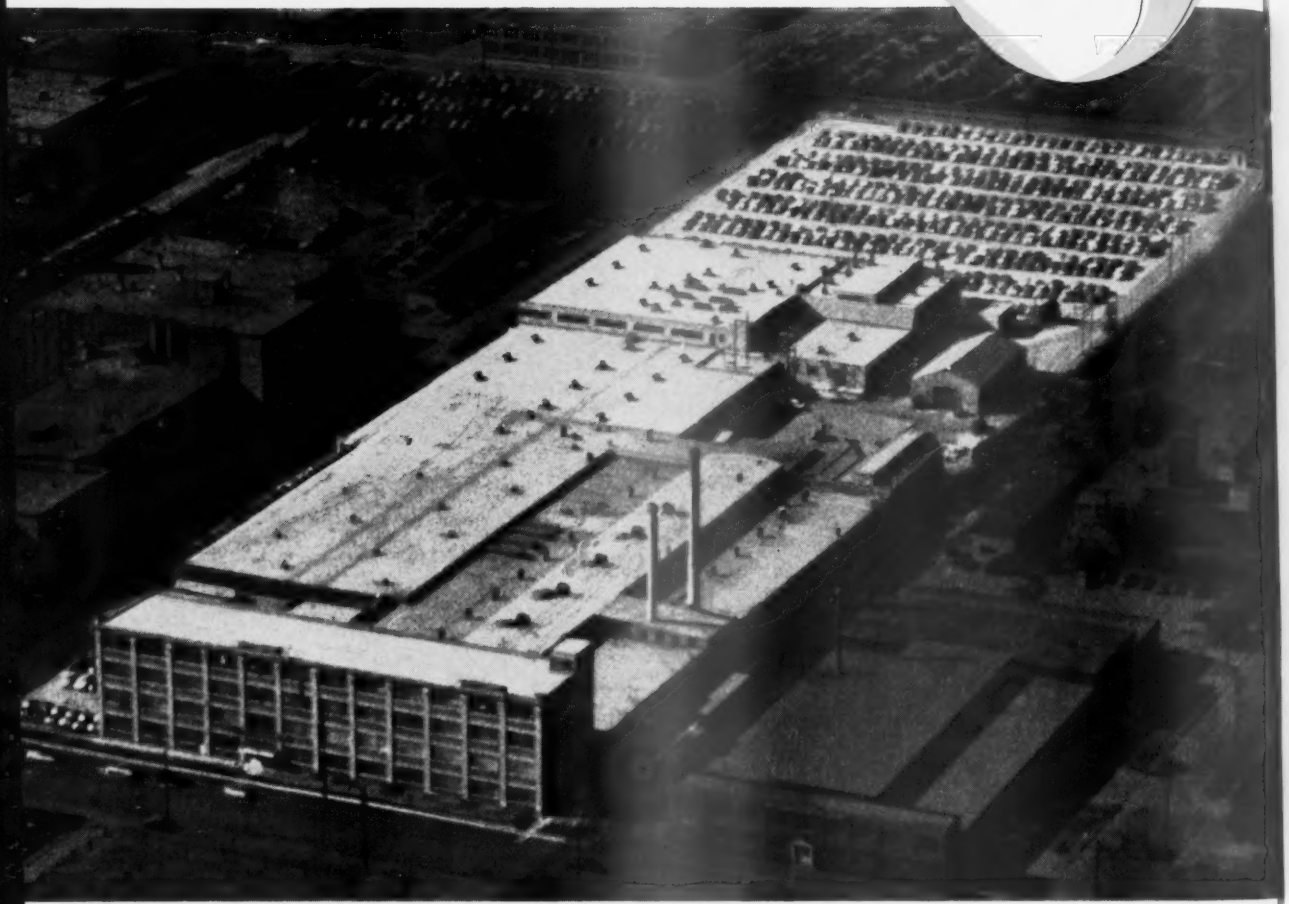
Aeronautical Engineering REVIEW

ELECTRONICS IN AVIATION **MAY, 1954**

Sundstrand announces new Aviation Division

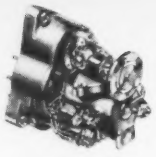
SUNDSTRAND



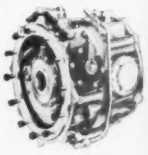
SUNDSTRAND AVIATION has been set up as a separate division of Sundstrand Machine Tool Company. This move represents another progressive step by Sundstrand toward its goal of establishing adequate production capacity for Constant Speed Drives and other specialized accessories for the Air Force, the Bureau of Aeronautics, and engine and airframe manufacturers.

The former Hydraulic Division of the parent company has been divided into two completely segregated entities, the Aviation Division and the Industrial Division. The Aviation Division will occupy the entire 250,000 square-foot plant shown above, which has heretofore been shared with the Industrial Division. All products of the Industrial Division will be manufactured in a new plant now under construction.

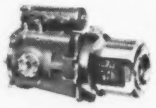
SUNDSTRAND AVIATION is now in a better position to serve the aviation industry. In addition to its doubled production capacity for Constant Speed Drives, it has its own management, sales, engineering, and service facilities. Please feel free to call upon us whenever you need help in solving an a-c power generation problem.



(Left) "Package-Type" Drive—can be strut or bracket mounted in line with power take-off pad.



(Right) "Sandwich-Type" Drive—extremely compact for mounting in nose cone, or other available pad.



(Left) "Cartridge-Type" Drive—mounts within engine gear box.

SUNDSTRAND AVIATION

Division of Sundstrand Machine Tool Company, ROCKFORD, ILLINOIS • Western District Office: Hawthorne, California

CONSTANT SPEED DRIVES • AIRCRAFT ACCESSORIES

Aeronautical Engineering Review

Vol. 13 — No. 5 May, 1954

CONTENTS

Some Recent Developments in Aviation Electronics ..... *Welman A. Shrader* 56

Integrated Electric Control for the General Electric J47-17 Jet Engine ..... *L. D. Brown* 59

Cooling Supersonic Electronic Equipment ..... *Doyle C. Wells* 70

The Role to Be Played by Training Devices in the Training of Aviation Personnel ..... *Edmund O. Carmody* 74

Liquid Cold-Plate Method for Cooling of Air-Borne Electronic Equipment ..... *Marshall P. Sandelin* 82

The Use of an Operational Flight Trainer as a Research Tool for Aircraft Instrumentation and Cockpit Rearrangement ..... *Joseph N. Pecoraro* 86

Operational Telemetering—An Aid to Air Navigation ..... *M. V. Kiebert, Jr.* 94

IAS News Notes 49
IAS News 51
Editorial 54
IAS Preprints 118
Aeronautical Reviews 141
Books 179
Personnel Opportunities 185
List of Corporate Members 188
Index to Advertisers 190
New Products and Product Literature 193

Cover—Symbolizing the "Systems Concept," a North American F-86D Sabre wheels over a ground control station radar antenna, while in the background the electronics and aeronautical engineers work together as a team. (Photos courtesy of North American Aviation, Inc., and The Glenn L. Martin Company.)

Published Monthly by the

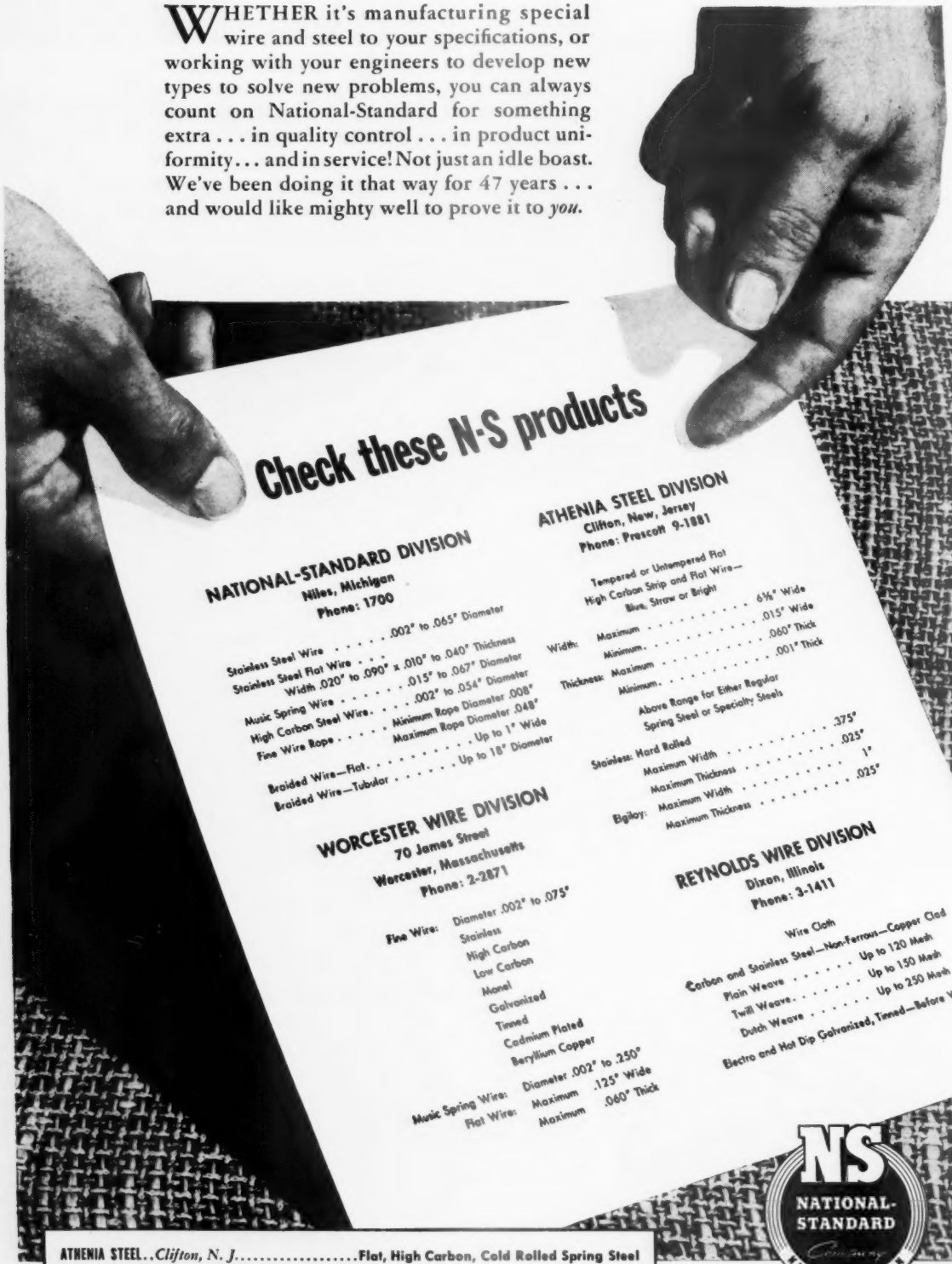
Institute of the Aeronautical Sciences, Inc.

2 East 64th Street, New York 21, N.Y.

Western Office: 7660 Beverly Blvd., Los Angeles 36, Calif.

Need special-purpose wire or steel?

WHETHER it's manufacturing special wire and steel to your specifications, or working with your engineers to develop new types to solve new problems, you can always count on National-Standard for something extra . . . in quality control . . . in product uniformity . . . and in service! Not just an idle boast. We've been doing it that way for 47 years . . . and would like mighty well to prove it to *you*.



Check these N-S products

NATIONAL-STANDARD DIVISION
Niles, Michigan
Phone: 1700

Stainless Steel Wire . . . . . .002" to .065" Diameter
Stainless Steel Flat Wire . . . .
Width .020" to .090" x .010" to .040" Thickness
Music Spring Wire . . . . . .015" to .067" Diameter
High Carbon Steel Wire. . . . .002" to .054" Diameter
Fine Wire Rope . . . . . Minimum Rope Diameter .008"
Maximum Rope Diameter .048"
Braided Wire—Flat. . . . . Up to 1" Wide
Braided Wire—Tubular . . . . . Up to 18" Diameter

ATHENIA STEEL DIVISION
Clifton, New, Jersey
Phone: Prescott 9-1881

Tempered or Untempered Flat High Carbon Strip and Flat Wire—Blue, Straw or Bright

Width: Maximum . . . . . 6⅜" Wide
Minimum. . . . . .015" Wide
Thickness: Maximum . . . . . .060" Thick
Minimum. . . . . .001" Thick

Above Range for Either Regular Spring Steel or Specialty Steels

Stainless: Hard Rolled . . . . . .375"
Maximum Width . . . . . .025"
Maximum Thickness . . . . . 1"
Bigley: Maximum Width . . . . . .025"
Maximum Thickness . . . . . .

WORCESTER WIRE DIVISION
70 James Street
Worcester, Massachusetts
Phone: 2-2871

Fine Wire: Diameter .002" to .075"
Stainless
High Carbon
Low Carbon
Monel
Galvanized
Tinned
Cadmium Plated
Beryllium Copper
Music Spring Wire: Diameter .002" to .250"
Flat Wire: Maximum .125" Wide
Maximum .060" Thick

REYNOLDS WIRE DIVISION
Dixon, Illinois
Phone: 3-1411

Wire Cloth
Carbon and Stainless Steel—Non-Ferrous—Copper Clad
Plain Weave . . . . . Up to 120 Mesh
Twill Weave. . . . . Up to 150 Mesh
Dutch Weave . . . . . Up to 250 Mesh
Electro and Hot Dip Galvanized, Tinned—Before Weaving

NS NATIONAL-STANDARD Company NILES, MICHIGAN

ATHENIA STEEL..*Clifton, N. J.*.....Flat, High Carbon, Cold Rolled Spring Steel
NATIONAL-STANDARD..*Niles, Mich.*.....Tire Wire, Stainless, Fabricated Braids and Tape
REYNOLDS WIRE..*Dixon, Illinois*.....Industrial Wire Cloth
WAGNER LITHO MACHINERY..*Jersey City, N. J.*.....Metal Decorating Equipment
WORCESTER WIRE WORKS..*Worcester, Mass.*.....Round and Shaped Steel Wire, Small Sizes

DIVISIONS OF NATIONAL-STANDARD CO.
NILES, MICHIGAN

I.A.S. News Notes

May 1954

IAS DIRECTOR AND SECRETARY AT AGARD MEETING IN HOLLAND

S. Paul Johnston, Director, and Robert R. Dexter, Secretary, left for Europe via MATS April 30, to attend the Fourth General Assembly of AGARD at Kurhaus, Scheveningen, May 3-7, as observer members of the U. S. Official Delegation.

Following the AGARD meetings, Mr. Johnston will spend four days in Stockholm, visiting SAAB, Svenska Flygmotor, and the Aeronautical Research Institute of Sweden. He plans to attend the latter's Symposium on High Speed Wind Tunnels, May 10-11, at the invitation of director, Dr. Bo Lundberg. (Dr. Lundberg, incidently, has been selected to deliver this year's Wright Brothers Lecture, December 17, in Washington.)

Mr. Dexter will proceed to London to visit the Royal Aeronautical Society and work out preliminary program arrangements for the Fifth International Conference.

Both men will look in on AFITA, and the Aero Club of France before returning to New York from Paris via MATS on May 16.

* * * * * *

ANNUAL SUMMER MEETING PROGRAM MAILED

All members planning to attend the Summer Meeting in Los Angeles should pay particular attention to the security forms and information pertaining to the Closed Session and Field Trip. Special forms have been enclosed with the programs mailed to all members the first of this month. Properly executed forms must be returned by MAY 31.

* * * * * *

NECROLOGY

Harold Victor (Bob) Wright, MIAS, Managing Director of Bristol Aeroplane Engines (Eastern) Ltd., died suddenly in March at his home in Rawdon, Quebec, Canada.

* * * * * *

NATIONAL MEETINGS CALANDER

June 21-24	Annual Summer Meeting, IAS Building, 7660 Beverly Blvd., Los Angeles, California
Aug. 9-11	Turbine Powered Air Transportation Meeting, Seattle, Wash.
Dec. 17	Eighteenth Wright Brothers Lecture, Washington, D. C.

* * * * * *

I.A.S. News Notes (con't.)

CALENDAR OF SECTION MEETINGS

May 6--Baltimore Section: Aberdeen Proving Ground. Dinner, 6:30 p.m. Inspection tour, 8:00 p.m. Wind-tunnel and computing facilities to be discussed by Charles Poor.

May 8--San Diego Section: IAS Building. Second Annual Spring Dance, 9:00 p.m.

May 11--San Diego Section: IAS Building. Meeting, 7:45 p.m. Program of films to include United Aircraft Corporation's, "I Saw It Happen."

May 12--Hagerstown Section: Location unknown at press time. Spring Dinner meeting, tentatively 6:30 p.m. Speaker, Grover Loening.

May 13--Los Angeles Section: IAS Building. Specialist meeting, 7:30 p.m. "Applications of Operations--Research Techniques of Air-Borne Weapon Systems Planning" by Robert A. Bailey, Lockheed Aircraft.

May 20--Baltimore-Washington-Hagerstown Sections: Remsen Hall, Johns Hopkins University. Joint meeting, 8:30 p.m. "Description of Russian MIG-15" by Major Gen. Albert O. Boyd, USAF, WADC, Security classification: SECRET.

May 20--Los Angeles Section: IAS Building. Social hour, 6:00 p.m.; Dinner, 7:00 p.m.; Meeting, 8:15 p.m. Speaker, Edgar Schmued, Vice-President - Engineering, Northrop Aircraft, Inc. Subject unknown at press time.

May 26--Detroit Section: Small Auditorium, Engineering Society of Detroit, Rackham Educational Memorial. Meeting, 8:00 p.m. "Rocket Power Plants" by Magnus von Braun. Joint meeting with Industrial Mathematics Society and Aero Club of Michigan.

May 26--St. Louis Section: Forest Park Hotel. Dinner meeting, 6:30 p.m. Winning papers of Annual Student Paper Competition to be delivered in the afternoon; awards to be presented in the evening.

May 27--New York Section: Kohler's Swiss Chalet, Rochelle Park, N. J. Dinner, 7:00 p.m.; Meeting, 8:00 p.m. "The Vickers Viscount Airplane" by Allen Greenwood, of Vickers. Meeting Chairman, Christopher Clarkson.

May 27--Los Angeles Section: IAS Building. Specialist meeting, 7:30 p.m. "Theory of a Digital Differential Analyzer and Its Application to Aerodynamic Problems" by L. C. Michels, Bendix Computer Div., Bendix Aviation Corporation.

May 27--San Diego Section: IAS Building. Social hour, 6:30 p.m.; Dinner, 7:00 p.m. Speaker, T. G. Lanphier, Jr., Vice President, Convair. Subject unknown at press time.

June 10--Los Angeles Section: IAS Building. Specialist meeting, 7:30 p.m. "Extension of Power Spectro Methods of Generalized Harmonic Analysis and Application to Aircraft Problems" by Bernard Mazelsky, Lockheed Aircraft Corporation.

* * * * * * * *

IAS News

A Record of People and Events of Interest to Institute Members

Preliminary Announcement of 1954 Annual Summer Meeting

Meeting to Be Held June 21 to 24; Ten Technical Sessions, Banquet, and Field Trip Scheduled

THE 1954 ANNUAL SUMMER MEETING of the Institute of the Aeronautical Sciences will be held, as is customary with the summer meeting, at the Institute's building at 7660 Beverly Blvd., Los Angeles. The meeting will get under way at 9:00 a.m., Monday, June 21, and will end Thursday evening, June 24.

One of the high points of this 4-day meeting will be the Transonic Testing Techniques Sessions at which papers on transonic wind-tunnel test sections will be delivered. The subject matter to be discussed in these papers was only recently declassified by the NACA. Among the session speakers will be two NACA staff members who will discuss the work of NACA in this field. Speaking for Langley Aeronautical Laboratory will be John Stack, winner of The Sylvanus Albert Reed Award for 1952 "for his leadership in the design, development, and practical operation of transonic wind tunnels." The other NACA speaker will be from Ames Aeronautical Laboratory; his identity, however, was not known at press time. Other organizations working in this field have been invited to participate. This transonic session will be chairmanned by Dr. Hugh L. Dryden, Director of NACA, and will begin at 9:00 a.m., Thursday, June 24.

Also scheduled for June 24, the final day of the meeting, are a field trip to Edwards AFB, Calif., and a Confidential Session, which will begin at 8:30 p.m. Confidential security clearances are required for the field trip, as well as for the evening session.

Another high point of the summer meeting will be the Annual Summer Meeting Banquet to be held on Wednesday evening, June 23, in the Pacific Ballroom of the Hotel Statler, Los Angeles. This banquet will have as its theme, "Our Shrinking Globe," and will mark the thirtieth anniversary of the U.S. Army Air Service's round-the-world flight. As will be recalled, four "World Cruisers," built by Douglas Aircraft Company, Inc., took off from Santa Monica, Calif., for Seattle, Wash., on March 17, 1924. On April 6, they left Seattle and 26,345 miles and 175 days later returned to Seattle, landing there on September 28. This was the first aerial circumnavigation of the earth.

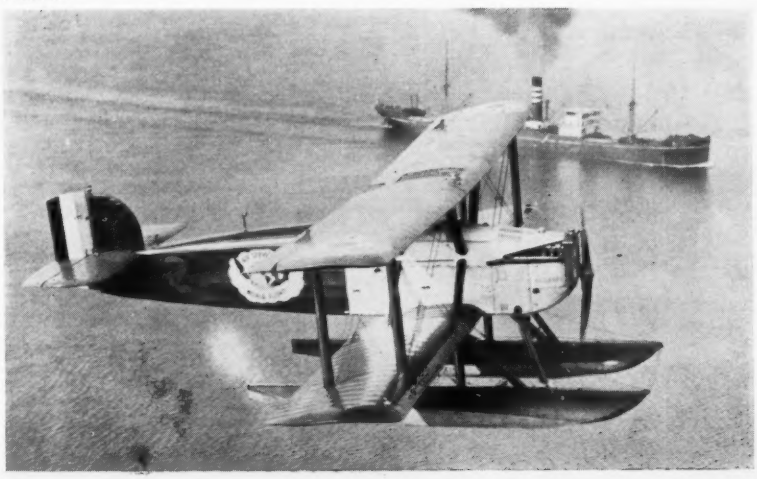
Donald W. Douglas, President of Douglas and an IAS Past-President, will be one of the banquet speakers. The toastmaster will be J. L. Atwood, IAS President and President of North American Aviation, Inc.

The remainder of the program consists of eight technical sessions. These sessions and their chairmen are as follows:

▸ **Monday, June 21**—*Accessory Design Problems*, 9:00 a.m.; Chairman, Homer Wood, Engineering Consultant. *Electronics and Aircraft Electrical Systems*, 1:30 p.m.; Chairman, John R. Moore, Associate Director, Electrical Mechanical Engineering Department, North American Aviation, Inc. *Military Aircraft and Weapons Operations*, 8:00 p.m.; Chairman, Edgar Schmued, Vice-President — Engineering, Northrop Aircraft, Inc.

▸ **Tuesday, June 22**—*Operational Flight Problems*, 9:00 a.m.; Chairman, George Mellinger, Chief of Flight Test, North American Aviation, Inc. *Human Problems of Flight*, 1:30 p.m.; Chairman, Dr. John R. Poppen, Consultant in Aviation Medicine, Douglas Aircraft Company, Inc. *Aspects of Heavy Skin Construction*, 8:00 p.m.;

Among the early aerial feats that demonstrated the theme of the 1954 IAS Annual Summer Meeting Banquet, "Our Shrinking Globe," was the U.S. Army Air Service's 1924 round-the-world flight. The "Chicago," one of the participating Douglas-built "World Cruisers," is shown.



Chairman, Leo Carter, Vice-President, Douglas Aircraft Company, Inc. ▶ **Wednesday, June 23**—*Aerodynamics*, 9:00 a.m.; Chairman, Dr. Clark B. Millikan, Director, Guggenheim Aeronautical Laboratory, California Institute of Technology. *Structures*, 1:30 p.m.; Chairman, Jerome F. McBrearty, Chief Structures Engineer, Lockheed Aircraft Corporation.

U.S. Rubber Joins IAS

The United States Rubber Company, a new Corporate Member of the Institute of the Aeronautical Sciences, has always been closely associated with the aircraft industry in the development and fabrication of new designs and constructions of airplane tires and tubes. In fact, the first plane to use rubber-tire wheels was equipped with tires made by the company under the "G & J" brand. The company also manufactures self-sealing and nonself-sealing fuel cells for aircraft fuels and lubricants; special cells for water-alcohol solutions and propellant acids; and flat sheet and formed parts from glass cloth and polyester resins. In addition, U.S. Rubber serves the industry with a comprehensive line of hose, ducts, asbestos connections, seals, propeller boots, electrical cables, and instrument mountings, all of which are engineered to modern aeronautical requirements.

Central sales and engineering offices are located at 6600 E. Jefferson Ave., Detroit 32, Mich. (tires and tubes); Mishawaka, Ind. (fuel cells); and 1230 Avenue of the Americas, New York 20, N.Y. (hose, ducts, seals, cables, and instrument mountings).

Consulting Firm of R. Dixon Speas Becomes Corporate Member

R. Dixon Speas, Aviation Consultant, engages in management, engineering, and operational analyses concerning present and future aspects of aviation development. Emphasis is directed to projects in the area of air transport, with particular respect to flight equipment and its operation.

Mr. Speas may be reached at the following address: P.O. Box 695, LaGuardia Airport Station, Flushing 71, N.Y.

IAS Members Serve with NACA

The following members of the Institute of the Aeronautical Sciences are among those aeronautical engineers and scientists who have been appointed or reappointed to serve on NACA committees and/or subcommittees during the current calendar year:

Eugene F. Baird, TMIAS, Chief, Flutter and Vibration Section, Research Department, Grumman Aircraft Engineering Corporation, was appointed to the Vibration and Flutter Subcommittee.

Leroy R. Grumman, HFIAS, Chairman, Board of Directors, Grumman, was named to the Industry Consulting Committee.

Alexander Kartveli, FIAS, Vice-President and Chief Engineer, Republic Aviation Corporation, was appointed to the Committee on Aerodynamics.

Dr. Hans W. Liepmann, FIAS, Professor of Aeronautics, California Institute of Technology, was appointed to the Special Subcommittee on Aircraft Noise and was reappointed to the Subcommittee on Fluid Mechanics.

Dr. Frank E. Marble, MIAS, Associate Professor of Jet Propulsion and Mechanical Engineering, CalTech, was reappointed to the Subcommittee on Combustion.

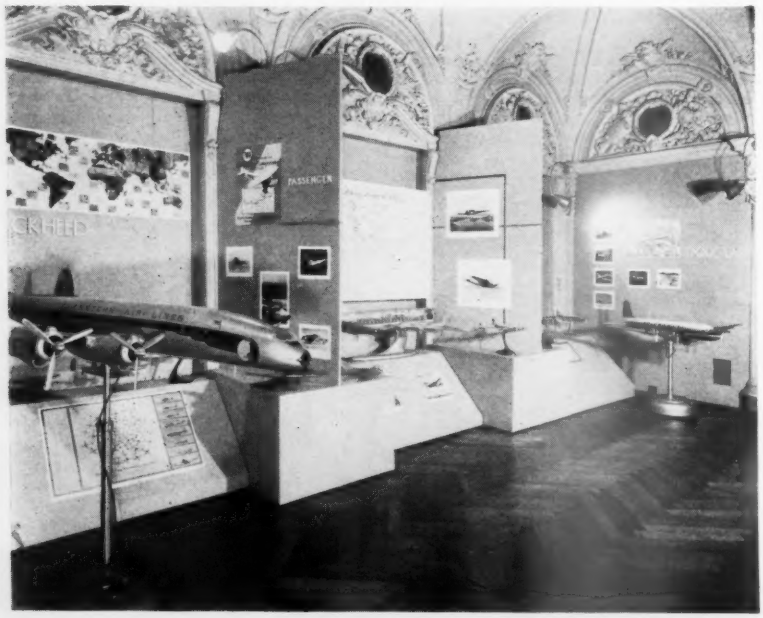
Dr. Clark B. Millikan, HFIAS, Professor of Aeronautics and Director of the Guggenheim Aeronautical Laboratory, CalTech, and Director of the Southern California Cooperative Wind Tunnel, was reappointed Chairman of the Subcommittee on Fluid Mechanics and to the Committee on Aerodynamics.

Dr. William J. McDonnell, MIAS, Chief Development Engineer, Republic, was appointed to the Committee on Aerodynamics, was reappointed Chairman of the Subcommittee on Internal Flow, and was reappointed to the Subcommittee on Engine Performance and Operation.

(*Continued on page 103*)

Gabriel M. Giannini, AFIAS, President of G. M. Giannini & Company, Inc., has donated the sum of $5,000 to the Institute of the Aeronautical Sciences. This fund is being used to establish and maintain the Giannini Film Library through which films will be loaned gratis to various IAS groups, especially the Student Branches. A comprehensive listing of films available from industry and the Institute is now being prepared; this will be issued periodically as part of the service rendered by the Giannini Film Library.

An exhibition of air transportation through the years, which included the current status of American civil aviation, was staged last February at the Aeronautical Museum of the Institute of the Aeronautical Sciences in New York. This show, a portion of which is shown, was entitled "A Pageant of Transport Aircraft." Models and materials for this special exhibition were provided by the following five transport aircraft companies and five air lines: Boeing Airplane Company; Consolidated Vultee Aircraft Corporation; Douglas Aircraft Company, Inc.; Lockheed Aircraft Corporation; The Glenn L. Martin Company; American Airlines, Inc.; British Overseas Airways Corporation; Eastern Air Lines, Inc.; Trans World Airlines, Inc.; and United Air Lines, Inc.



Tentative Program for National Telemetering Conference

The 1954 National Telemetering and Remote Control Conference will be held at the Morrison Hotel in Chicago on May 24, 25, and 26. The sponsors of this forthcoming meeting are the Institute of Radio Engineers, Instrument Society of America, American Institute of Electrical Engineers, and Institute of the Aeronautical Sciences.

The program planned for this 3-day meeting consists of the Annual Banquet on the evening of the second day, a luncheon on the final day, an evening session on the first day, and six daytime sessions. (For specific times of these events, see Time Schedule below.)

The speaker at the Annual Banquet will be Everett S. Lee, of General Electric, an AIEE Past-President. Conrad H. Hoeppner, of W. L. Maxson Corporation, will deliver the luncheon address on "Telemetering and Remote Control, Future Applications."

A general discussion paper is planned for the evening Workshop Session. The title of this paper, by W. J. Mayo-Wells and E. Lynch, is "Classification of Telemetering Systems." Session Chairman will be Mr. Mayo-Wells.

Between four and six papers will be delivered at each of the six 3-hour daytime technical sessions. The presentation time of each paper will vary from 15 to 25 min., with the balance of the session being taken up with the introductions of the speakers and question-and-answer periods. The papers to be given at the various sessions are as follows:

Telemetering Systems (Chairman, Frank P. Lehan)—"Microwave Telemetering" by R. G. Ralman; "A Large Research and Development FM/FM Telemetering System for Extreme Environmental Conditions" by A. W. Newberry; "A Transistorized FM/FM Telemetering System" by R. E. Colander and C. M. Kortman; "Selective Telemetering Application" by L. G. Walker; "Telemetering of the Illinois-Missouri Electric Power Pool" by G. W. Fox, D. F. Hazen, H. E. Stites, W. S. Bloor, and T. W. Hissey; and "Recorder Computing Techniques Used in the Measurement of Electric Power and Associated Quantities" by W. E. Phillips.

Telemetering Pickups and Components (Chairman, James Wynn)—"Application of Transistors to Telemetering Components" by C. M. Kortman; "A New Sub-Carrier Oscillator" by E. L. Tarca; "A New Panoramic Instrument for Analyzing and Calibrating FM/FM Telemetering Systems" by W. I. L. Wu; "New High Stability Component Configurations Solve Telemetering Systems Design Problems" by L. A. G. ter Veen; and "Movable Core Transformer as a Pickup for Industrial Telemetering Systems" by A. J. Hornfeck.

Remote Control—Digital (Chairman, Perny Crawford, Jr.)—"An Electronic System for Air Traffic Control Information" by R. M. Kalb; "Remote Shaft Positioning Via Frequency Code Data Transmission Systems" by H. B. Shultheis; "Some Fundamental Limitations and Capabilities of Sampled Data Systems" by W. K. Linvill; and "A Proposed Air Traffic Control System" by B. Gordon.

Remote Control—Analogue (Chairman, George R. Barton)—"Application of Analogue Computers to Sampling Control Systems" by H. Meissenger and A. Karen; "Automatic Helicopter Positioning Thru Present and Future Gyro Pilot Control" by J. Grano; "Application of Raydist to Remote Helicopter Control" by J. T. Bradbury and A. Comstock; "Design of High Performance Hydraulic Control System" by M. Feder and K. Bailey; and "A Damper Stabilized Servo Data Repeater" by J. E. Ward.

All Weather Flight Control (Chairman, David S. Little)—Program not finalized at press time, but it is to include various problems and plans associated with the all-weather flight control problem.

Information Handling—Data Reduction (Chairman, Bernard S. Benson)—"Problems in Telemetry Data Reduction" by D. Belloff; "Cost Reduction in Data Reduction" by D. B. Prell; "A System for Recording and Reducing Airplane Flight Data" by R. E. Colander and D. Evans; "A New Instrumentation Tape Recorder" by C. C. Shaw; and "A New Data Reduction Facility for PWM-FM Telemetry" by F. Bryant.

Time Schedule

Monday, May 24	Tuesday, May 25	Wednesday, May 26
Telemetering Systems Session 9:30 a.m.–12:30 p.m.	Remote Control—Digital Session 9:30 a.m.–12:30 p.m.	All Weather Flight Control Session 9:30 a.m.–12:30 p.m.
		Luncheon 12:45–2:15 p.m.
Telemetering Pickups and Components Session 2:00–5:00 p.m.	Remote Control—Analogue Session 2:00–5:00 p.m.	Information Handling—Data Reduction Session 2:30–5:30 p.m.
Workshop Session 8:00 p.m.	Annual Banquet 7:30 p.m.	

Editorial

The Systems Concept

For the fourth consecutive year, the Institute has devoted at least one full day of its Annual Meeting to the subject of Electronics in Aviation. More and more papers along these lines have been encouraged at Section, Branch, and other national meetings. Plans for the future include whatever added emphasis is necessary to keep pace with this increasingly important aspect of aeronautical development.

Electronic theory, per se, is not the Institute's primary field of interest. What goes inside the "little black boxes" is the particular problem of the electrical and electronics engineer. His knowledge of amplifiers, vacuum tubes, transistors, and all the rest provides the basis for equipment that can be used to extend the performance capabilities of aircraft. Our job is not only to encourage the further development of such equipment but also to correlate the thinking of the electronics and the aeronautical engineer during the early stages of design.

This correlation, known as the "systems concept," has been largely responsible for the rapid rate of development of aircraft and missiles since World War II. The integration of aerodynamic, electronic, and other specialists within individual company engineering departments has brought about clearer understandings and quicker solutions to all the problems involved. Where engineers work side by side, the ideas and designs of each can be compatibly integrated into the efficient end-product desired by all.

The systems concept is not new to the Institute. For many years this organization has advocated and sponsored the joint cooperation of other professional societies in the discussion of all subjects of mutual interest. Electronics is just one of these—but an extremely important one.

Through continued cooperation with the various groups and societies specializing in this field, we seek to create a better understanding of this concept. This special issue of the REVIEW is but one more tool designed for this purpose. W.A.S.

Some Recent Developments in Aviation Electronics

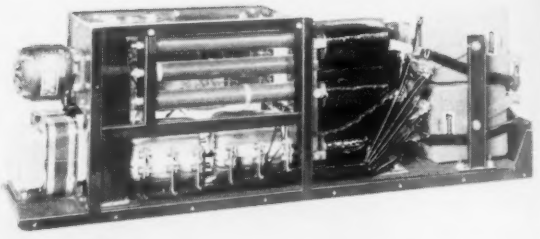
By Welman A. Shrader

THE FIELD of aviation electronics has become so broad and its growth so rapid that it is almost impossible for the average person to keep pace with the many facets of its present development. Electronics for aviation has become big business. So big, in fact, that it bids well eventually to outstrip in volume the aircraft industry it was designed to augment.

From concept to completion of its mission, today's aircraft is more than ever dependent upon electronic devices. Giant "brains" are called upon to solve the multiplicity of problems connected with its design, testing, and performance. Electronic simulators train its pilots. Automatic controls and complex navigational instruments take over the burdensome work in its cockpit. Radar, radio, and telemetering systems guide it to its destination, track its targets, fire its guns, and bring it safely home in all kinds of weather.

Thus, the amplifier and the servo have become as important to the aircraft as the airfoil and the power plant. The companies that develop and produce electronic devices and equipment have an increasingly larger stake in this aviation business.

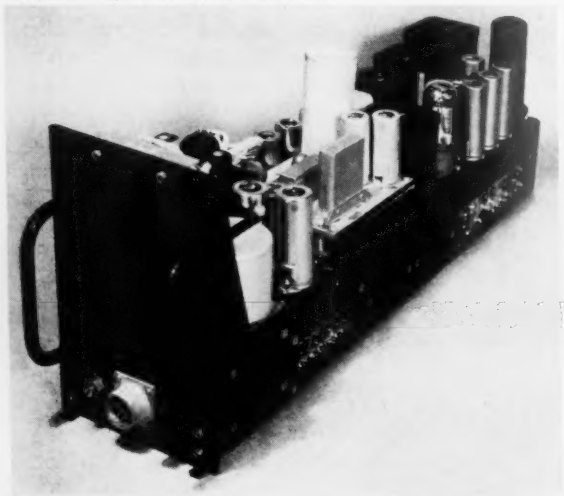
The primary purpose of this article is to call the attention of the aeronautical engineer to some of the current developments in various types of aviation electronic equipment. Obviously, it is impossible to include all of the hundreds of items and companies currently contributing to this field. The randomly selected, unclassified devices portrayed in the following pages are merely indicative of the potentials of the aviation-electronics art.



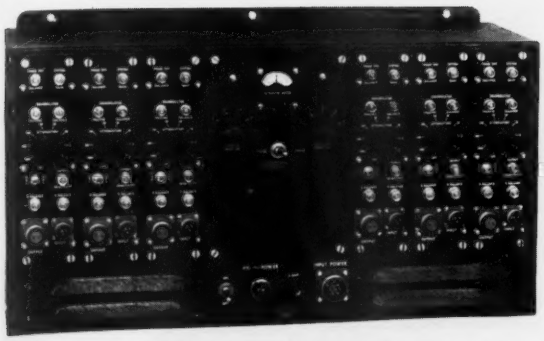
This transformer rectifier, produced by the Federal Telephone & Radio Corporation, is a regulated a.c. to d.c. conversion unit for use on a 200-volt, 400-cycle system. It consists of a transformer, a selenium rectifier, a magnetic amplifier voltage regulator, and a blower, compactly mounted in a steel housing.

Cutaway model of Sperry Gyroscope Company's recently announced Vibratory Gyro, showing the U-shaped vibrator prongs.

W. L. Maxon's Precision Frequency Regulator for Aircraft Inverter is used for high-precision rate gyros and fire control and navigational systems' motors and servos.

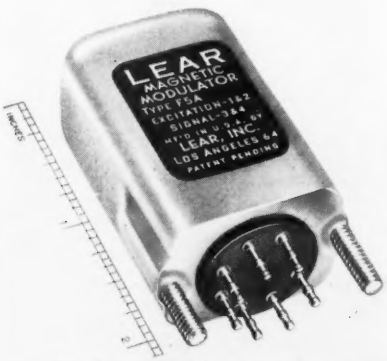


Temperature control amplifier, designed and manufactured by the Aircraft Products Division of Manning, Maxwell & Moore, Inc., is used to modulate the exhaust-nozzle area of a turbojet engine in order to maintain a constant turbine exit temperature. The input signal is derived from thermocouples, and the output controls a servo that supplies hydraulic power to the exhaust-nozzle positioning actuators.

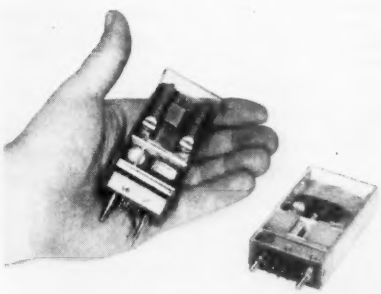


A Six-Channel Amplifier Demodulator, recently developed by the Doelcam Corporation.

Graph-like patterns on the screen of a Sperry air-borne analyzer tell the flight engineer how working parts of the four engines of his aircraft are behaving.

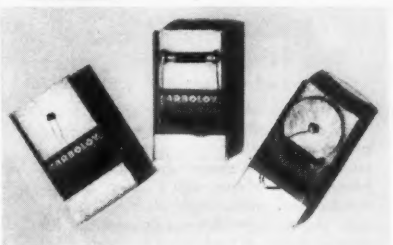


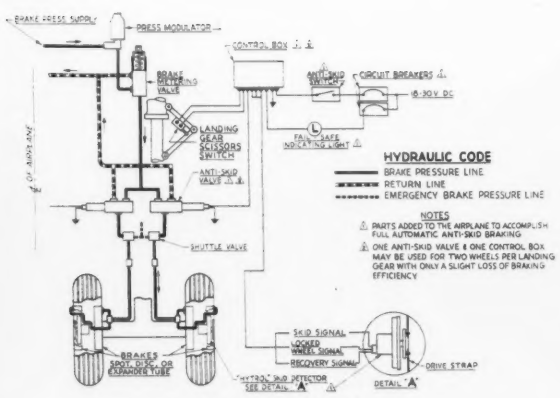
The Lear Model F5A Magnetic Modulator is especially designed for accurate and stable conversion of low-level d.c. signals to proportional a.c. signals more suitable for electronic amplification.



Two amplifiers (trigger and video), developed by Cornell Aeronautical Laboratory, Inc., are typical examples of the reliable subminiaturized electronic subassemblies that have been achieved.

Electronic elements have become so miniaturized that special packaging is required to identify or keep track of them. Carboloy Department of General Electric Company developed these cellulose acetate packages to accommodate some 69 different varieties of their thermistors.

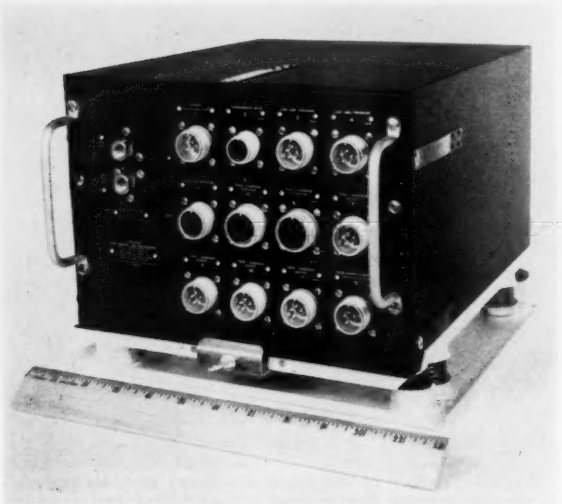




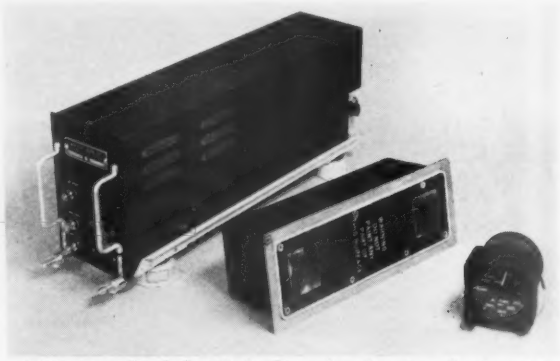
HYDRAULIC & ELECTRICAL SCHEMATIC FOR "HYTROL" SYSTEM

The antiskid braking system developed by Hydro-Aire employs electronic sensing and power units to give automatically smoother, more efficient stops to large aircraft.

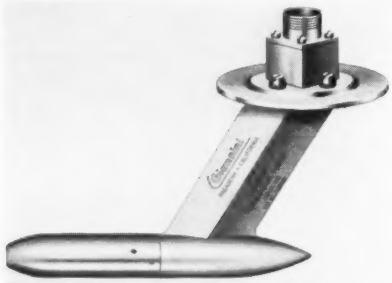
General Electric's G-3 autopilot is a compact, sturdy, easy-to-control system designed specifically for new jet interceptor-, fighter-, and attack-type aircraft.



The new Kollsman C-2 True Airspeed Computer, designed to act as a central data source on high-speed, high-altitude aircraft, will furnish multiple outputs of atmospheric pressure, Mach Number, and true air speed. This information may be directed to control navigation, bombing, gun fire control, and photographic equipment and to provide visual indication for the flight crew.

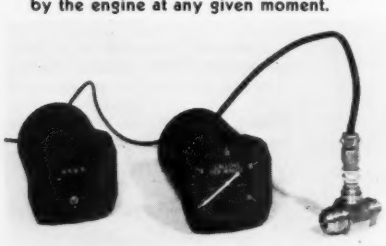


Only recently declassified, this radar altimeter, developed by Raytheon Manufacturing Company, keeps the pilot constantly informed of his exact height above the surface of the earth.

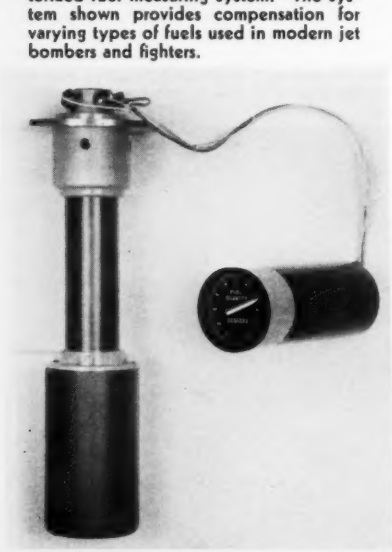


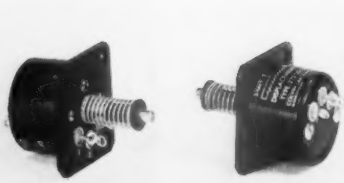
The Giannini Dual Unit Pressure Transmitter can be used to obtain Mach Number indication since it contains two pressure transmitters; one that measures static pressure and the other that measures the differential of static and pitot pressures. The Giannini Adiabatic Temperature Probe can be used to modify the output of the Machmeter to obtain true air-speed information.

The Potter Electronic Flowmeter, consisting of a flow sensing element, a rate indicator, and a totalizer, accurately measures how much fuel is being consumed by the engine at any given moment.



A combination gage and transistorized power unit *(right)* and a greatly improved tank-sensing element are features of Minneapolis-Honeywell's new transistorized fuel measuring system. The system shown provides compensation for varying types of fuels used in modern jet bombers and fighters.





Displacement transducers, available for strokes from 0.1 to 0.5 in. and used for telemetering the position of a control element of a missile or as part of the feedback circuit for a servo system, are a product of Colvin Laboratories, Inc.

Avien Capacitance-Type Fuel Gage is based on self-balancing bridge principle. System has been reduced to two units for lightest weight and installation simplicity. All electronic circuitry is housed within the indicator case.

(Continued on page 68)

Integrated Electric Control for the General Electric J47-17 Jet Engine

L. D. BROWN*
General Electric Company

Introduction

THIS INTEGRATED ENGINE CONTROL system is a significant forward step in automatizing jet aircraft operation. The J47–17 engine-Integrated Electric Control team powers the new North American F86–D interceptor. Single-lever control of the engine is provided through all ranges of operation, from the initial starter whirl to full power output. Control of this new engine, equipped with an afterburner for added thrust, is handled by several carefully interrelated servo systems. The signals that are fed to the control system are electrical in nature. Electric-motor actuators are the primary muscles of the control; these actuators modulate engine and afterburner fuel flow and tailpipe variable nozzle area. The major objective of this control system is to get the most thrust out of the engine, within safe operating limits, with minimum pilot attention. Effects of altitude and speed on powerplant performance are minimized.

This discussion will endeavor to bring out the following:

(1) A brief description of the engine to be controlled.
(2) The philosophy and control methods used.
(3) Major engineering problems involved.

No attempt will be made here to describe the separate emergency fuel control system used.

Background

In order to assure a mutual background of understanding, we shall review briefly the fascinating picture of the modern jet engine's operation. The basic engine will first be discussed; the ramifications of adding an afterburner for added thrust will then be explained. An earlier control system will be touched on briefly.

Let us first consider the standard J47 aircraft turbojet engine (Fig. 1) without the afterburner. This will briefly emphasize the factors that are most significant in controlling the engine. Major elements are the air inlet, rotor (compressor and turbine), burners, turbine, tail cone, and tailpipe (not shown). The tailpipe extends to the right of the outer exhaust cone shown. (Physically this is an air machine.) Air, in the order of tons per minute, is scooped in at the air inlet, receives heat energy in the burners, and is discharged at high velocity. The control problem is basically maintaining or varying thrust at the will of the pilot, within engine limitations. Thrust, at a given altitude, is determined by *rotor speed* and *tailpipe temperature*. The rotor speed is controlled by means of controlling the input fuel flow. The tailpipe temperature is a rather intricate function of both rotor speed and of the area of the nozzle formed at the tailpipe exit. In the engine shown in Fig. 1, this area is fixed.

It is also necessary to limit engine operation in several ways. For one thing, it is necessary to maintain a combustible mixture in the burners. A problem arises here because of the increasing thinness of the air at higher altitudes. In jet-engine operation, there are several areas of major importance which have been avoided. These are: (1) compressor stall; (2) engine blowout; (3) overtemperature; (4) overspeed. By compressor stall is meant a kind of flow reversal through the compressor blading, which starves the combustion system of air and will burn up the engine quickly if allowed to persist because of the excessive richness of the mixture in the combustion system. By blowout is simply meant having the mixture either so lean or so rich that combustion cannot be supported. Rich burner blowout and compressor stall, while not the same, are related phenomena; both must be prevented. Most critical to overtemperature and overspeed is the turbine wheel because of the high stresses that exist in the turbine blades.

Let us next consider the reheat engine (essentially the basic engine with an afterburner added), a cross section of which is shown in Fig. 2. The long cylindrical afterburner, at the full turbine wheel diameter, replaces the smaller tailpipe in the unaugmented engine. A variable-area nozzle is provided for the afterburner at the exhaust. In operation, fuel is injected downstream of the turbine wheel and burned. This afterburning is restricted to full engine speed. A variable-area nozzle is opened and shut as required to maintain pressure and temperature at the turbine discharge at the same values when on afterburning as during dry operation. It turns out that, by controlling the jet nozzle area to maintain the temperature that is sensed just downstream of the turbine wheel, we can hold the same turbine discharge conditions on reheat as at full dry power. By the term "dry" is meant "without reheat." Having a variable-area nozzle offers some advantages in engine control in the lower speed dry ranges, as well as in the high power settings. By using an afterburner, an appreciable increase in thrust

* Aeronautic Systems Engineering, Aeronautic and Ordnance Systems Division.

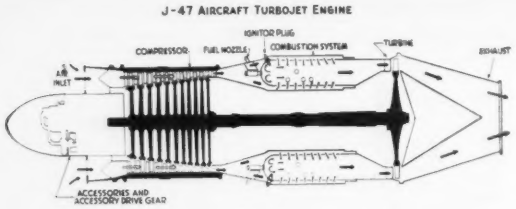


FIG. 1.

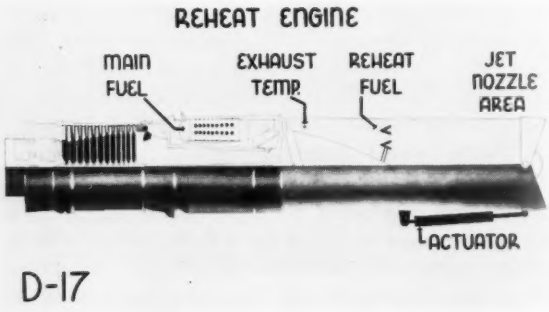


FIG. 2.

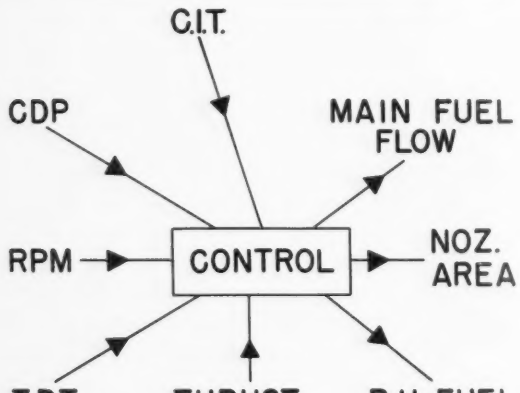


FIG. 3.

SUMMARY

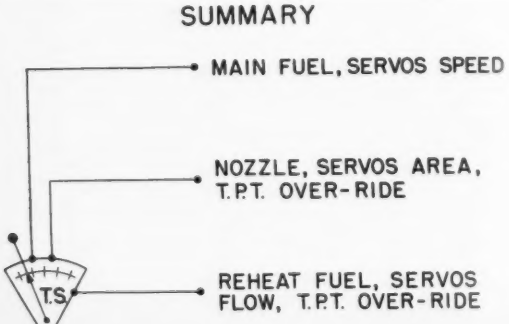


FIG. 4.

can be realized for an engine, although at the expense of a tremendous increase in total fuel consumption. The use of an afterburner is also attractive because net thrust tends to increase with increasing air speed to a greater extent than for a dry engine.

Basically, the control problem on a reheat engine is this:

(1) Where control of the amount of augmentation used in the reheat region is required, as it is here, the jet nozzle area must be varied to maintain tailpipe temperature and pressure.

(2) The same problem of maintaining a combustible mixture with variations in air density with altitude, as was shown to be the case for the main engine, is required in the reheat burner.

(3) Transients encountered during ignition of the afterburner, as well as coming off reheat, must be handled.

To get a brief picture of how the control job on the main engine has previously been handled, let us consider the VS-2 hydraulic regulator. This regulator has been used, and is being used, to control some versions of the J47 jet engine. This engine and regulator are used in the North American F86A, as well as in the Boeing B47. The control senses hydraulically and mechanically compressor discharge pressure and r.p.m. By sensing compressor discharge pressure, an indication of altitude is provided, as well as a measure of the amount of fuel which can be safely injected into the burners without causing stall. This control has a speed governor that the pilot resets by moving his control lever. The control varies the speed of the engine, in response to the pilot's wishes, by varying the fuel pressure to the main burners. The governor is what we call a "drooping" type—that is, the speed once set may vary somewhat with altitude and flight conditions. At each value of compressor discharge pressure (abbreviated C.D.P. in this paper), a maximum and minimum fuel pressure *available* is scheduled in by the control. Compressor discharge pressure is used as a measure of airflow through the engine. By thus placing limits on the amount of fuel which the pilot can pour into the burners, as a function of C.D.P., the engine is kept out of stall or blowout. Because of engine limitations, the range of speed control available, by the pilot's resetting the governor, is a function of C.D.P.; engine response to the control also becomes more sluggish as the altitude increases.

There are several limitations to the manner in which this control accomplishes its job in its application. These are:

(1) Engine speed and exhaust gas temperature, and hence per cent of maximum thrust output available, tend to vary somewhat with inlet air temperature and altitude.

(2) No temperature control is provided.

(3) Automatic starting is not provided.

For application to a reheat engine such as the J47–17, there are other serious limitations. No means for controlling afterburner fuel flow, or nozzle area, are provided in the regulator itself. This means that

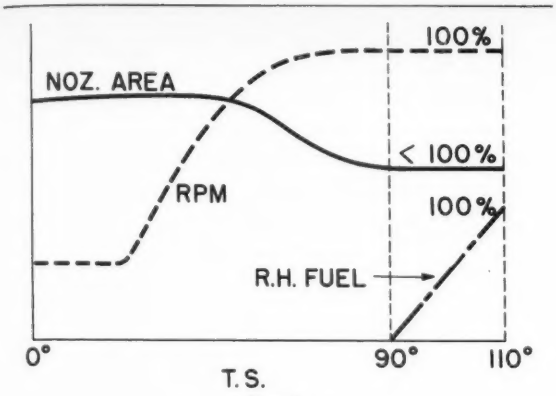


FIG. 5.

additional equipment would be required to do the job for such an application as this. The use of such additional equipment has been successfully accomplished on an experimental basis, but has not resulted in a satisfactory arrangement with regard to safety or pilot convenience.

INTEGRATED CONTROL PHILOSOPHY

This new control system was designed with applications to interceptor power-plant control in mind. Because of the magnitude of the pilot's job in the single-place F86-D, it is desirable that the power-plant control system be highly automatic.

To control this new reheat engine, it would have been possible to add nozzle control components and afterburner fuel control components to the VS-2 regulator. The second possible course would have been to start this job over, filling in the VS-2 regulator's deficiencies in such an application and integrating control of the nozzle, afterburner, and main engine. The latter course was taken.

The philosophy of this control system design has been to close several interrelated servo-loops, using engine response as part of each loop. The concept of a single-lever control has been kept in mind from the start. It was intended that an approximately straight-line relationship between engine thrust and the position of this "single lever" be maintained. To this end two steps have been taken: (1) Modulation of reheat is provided—that is, control within the reheat range. (2) A definite relationship between engine speed and nozzle area is held. A further objective has been to provide fast, temperature-controlled starts of the main engine. Rapid temperature-controlled accelerations were also sought for. Every effort was made to give the pilot maximum freedom in moving his control lever, eliminating throttle jockeying. This control lever arrangement was rather early given the title "Thrust Selector." As was mentioned earlier, a major objective has also been to keep the engine in safe operating regions of speed and temperature, free from compressor stall and blowout difficulties. The matter of reliability has been given careful consideration and is continuing to receive serious study.

Besides the present application of the Integrated Electric Control to the J47-17 reheat engine, it was also initially conceived that this system would be applied to a dry engine with little modification. The operating advantage of precise automatic control would be valuable in many dry engine applications.

BLOCK DIAGRAM OF THE INTEGRATED ELECTRIC CONTROL—SUMMARY OF THE CONTROL

Any control system receives certain signals and uses those signals to set things in motion as required. As shown in Fig. 3, the integrated control system receives signals for compressor discharge pressure, compressor inlet temperature, r.p.m., and tailpipe temperature from the engine. To this is added a signal from the pilot's control lever or thrust selector. In turn, the control sets main fuel flow, jet nozzle area, and reheat, or afterburner, fuel flow in response to all these input signals.

Fig. 4 summarizes the three major servo-loops used in the control: Main fuel flow is handled by a speed control servo, with a number of overriding circuits that keep the engine within safe operating limits. Jet nozzle area is handled by a position control servo. Protective means are provided so that this servo is used to maintain tailpipe temperature under certain conditions. Reheat fuel flow is controlled by a position servo. A motor-operated fuel valve does the job.

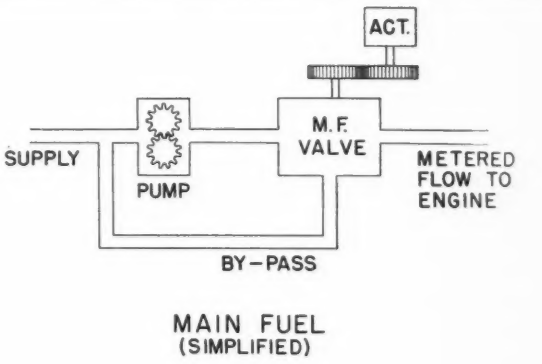


FIG. 6.

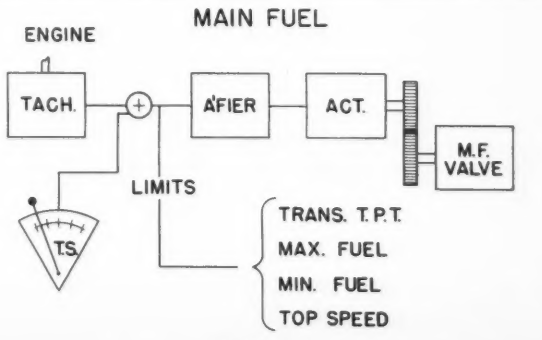


FIG. 7.

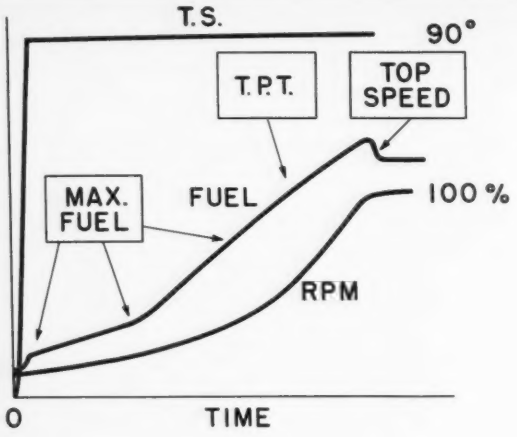


FIG. 8.

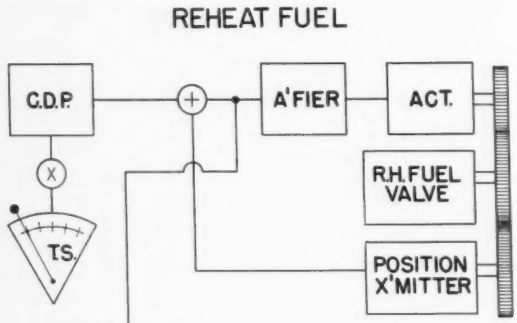


FIG. 9.

This channel also is depended upon to maintain tailpipe temperature under certain conditions to be described later. It will be noted that tailpipe temperature is an important parameter in this control system. The use of thermocouples as a control element in a relatively fast servo system has become possible only in the last few years. Thermocouples had previously been too slow, until extensive efforts in developing more satisfactory couples by General Electric resulted in a satisfactory control element. In view of the fact that the thermocouples are here used as a control element rather than merely an indicator suggests the use of the term "exhaust temperature sensor" as being more descriptive than "thermocouple."

The thrust selector, as it has been indicated, feeds signals or basic instructions to the control system. As pointed out in Fig. 5, as the pilot moves his thrust selector forward over the 0° to 110° range, the following occur:

(1) Starting from a low idle speed, engine r.p.m. rises to full speed near the 90° setting.

(2) Nozzle area is gradually scheduled closed, to somewhat less than 100 per cent at 90° and above. By 100 per cent is meant the area that is required to maintain a full-rated steady-state engine temperature under standard day conditions.

(3) As the thrust selector is moved past the 90° point, reheat fuel is scheduled to be introduced into the afterburner of the engine. Note that in the reheat region, the nozzle is scheduled at a small enough area so that an overtemperature will result. Maintenance of normal temperature requires that the overtemperature drive the nozzle open. The manner in which this is done will be explained later.

Main Fuel Control

As previously indicated, the main fuel control is basically a zero-droop, speed control servo. It is essentially an isochronous governor, maintaining precisely the selected speed under all flight conditions. The heart of this system is the main fuel valve (Fig. 6). The rotation of an actuator-driven input sets a metered flow into the engine burners from a positive-displacement pump. As shown by the diagram, the mechanism of flow control is essentially to by-pass the excess to the extent necessary to maintain the desired flow.

Fig. 7 shows the main fuel servo-loop. The speed element on the thrust selector calls for a given engine r.p.m., which is balanced against the engine-driven tachometer generator output. From this comparison, an error signal is derived. Ignoring the effect of the *limits* shown in Fig. 7, the valve then pours in fuel as needed to get the engine speed change required by this error signal. Limits are provided to keep the engine in a safe operating range. The effect of these limits is to stop or reverse the valve motion until the condition affected is relieved. In Fig. 7, a *transient tailpipe temperature limit* is shown. There is also a *steady-state tailpipe temperature limit*. Two temperatures are of interest in this control work: The first is the allowable peak temperature that is achieved briefly during an engine acceleration, for example. This we call a transient temperature limit. The second is a maximum temperature that is allowed to persist for an appreciable period of time. This we call steady-state temperature limit. The effect of the four limits

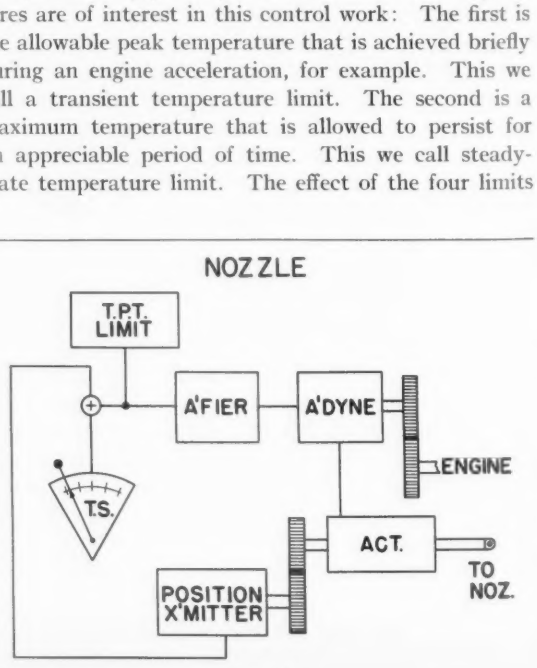


FIG. 10.

shown then will be to close down the valve as required:

(1) When this allowable transient tailpipe temperature is exceeded.

(2) When the maximum fuel limit is exceeded. This is the limit that keeps the engine out of stall and prevents blowout due to an overrich mixture. It is computed from the existing value of compressor discharge pressure and compressor inlet temperature.

(3) As the engine comes into top speed.

A minimum fuel limit will open the valve as required to prevent blowout due to an overlean mixture in the main burners.

Automatic engine starting is accomplished as follows: By advancing the thrust selector into the idle range, a fixed fuel flow is introduced into the main engine burners. After firing at this fuel flow, the *transient temperature limit main fuel* servo-loop governs acceleration. This temperature limit is depressed below its normal value because of the extreme sensitivity of tailpipe temperature to fuel flow changes in the speed range below ground idle.

Operation of the limits shown in Fig. 7, on a throttle burst, is described in Fig. 8. The thrust selector is instantaneously burst from the idle range to 90°. Shown are the motion of the main fuel valve, or the change in fuel flow, and the resulting speed response of the engine. While the thrust selector is moved rapidly, the fuel flow is held back from immediate sharp change by this *maximum fuel limit*. In the lower speed range, as shown here, the fuel valve will tend to open slowly as the compressor discharge pressure increases gradually with engine speed, thus increasing the maximum fuel limit. At the higher speeds, tailpipe temperature rises rapidly; the *temperature limit* restrains fuel flow change to hold this rise within bounds. As top speed is reached, the fuel flow is sharply cut back by the top speed limit, so that 100 per cent speed is reached without overshoot. Operation of the limit circuits is somewhat idealized in this picture; it is usually rather difficult to determine whether the maximum fuel limit or the transient tailpipe temperature limit is the element in control at any time during such an acceleration.

Reheat Fuel Control

In summarizing the control system, it was stated that the control of reheat (afterburner) fuel flow is accomplished by a position control servo. Fig. 9 shows the elements of this servo-loop. The reheat fuel valve basically does the same sort of job that the main fuel valve does—that is, it meters flow into the reheat burner of the engine dependent upon its input shaft position. In operation, the thrust selector schedules the value of reheat fuel flow when in the 90° to 110° region. This scheduled fuel flow is modified by the compressor discharge pressure transducer to call for a fuel value compatible with the inlet air density. This signal then is compared with the fuel valve position so

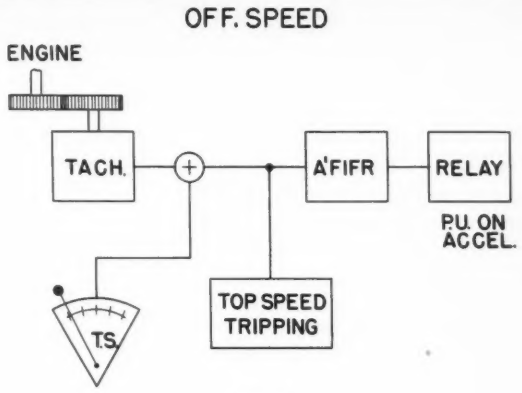


Fig. 11.

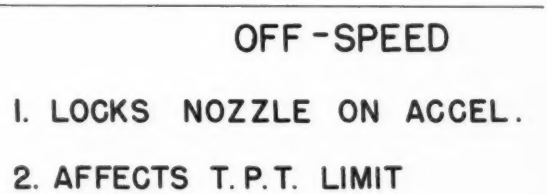
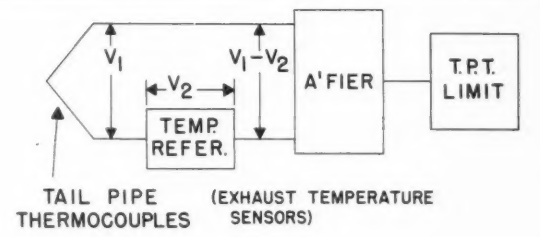


Fig. 12.



T.P.T. LIMIT GENERATOR

Fig. 13.

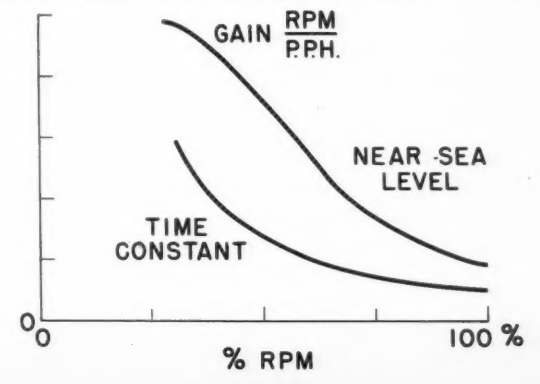


Fig. 14.

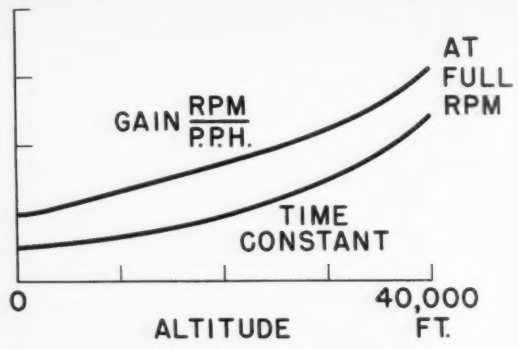


FIG. 15.

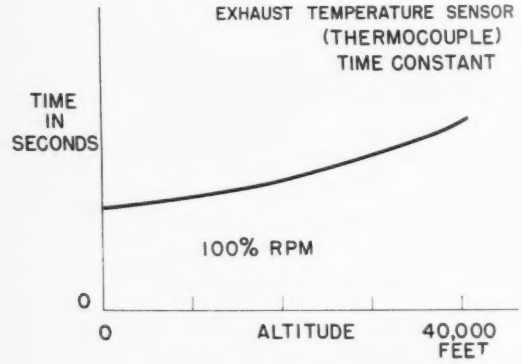


FIG. 16.

that an error signal is derived. This error signal drives the fuel valve through an amplifier and actuator in such a manner as to get the required fuel. The steady-state temperature limit is applied to the error signal so that, if the allowable tailpipe temperature is exceeded, the reheat fuel flow will be decreased.

NOZZLE AREA CONTROL

As shown in Fig. 10, this is a position control servo with a steady-state tailpipe temperature limit override. The elements involved besides the thrust selector are an amplifier channel, an engine-driven amplidyne, and an actuator. The actuator is d.c. motor driven. The thrust selector nozzle position signal is compared to the actuator position, deriving an error signal. The amplified error signal then drives the actuator to open or close the variable-area nozzle as required. The steady-state tailpipe temperature limit on the nozzle is set at a somewhat lower temperature than is this limit on reheat fuel flow. The purpose of this is to establish a sequence of temperature take-over in the reheat region. The nozzle is arranged to act first when an overtemperature occurs. Under most conditions, the nozzle will hold temperature so that the temperature limit does not have to operate on reheat fuel flow. It is important to note that, while the schedule calls for the nozzle to be closed during reheat operation, the nozzle is actually opened by the operation of the steady-state temperature limit.

OFF-SPEED CHANNEL

The effect of this channel (Fig. 11) was not shown in the summary. However, it is an important element that relates a number of operations to engine speed and acceleration conditions. Using the speed element of the thrust selector and the tachometer, the speed error signal will pick up the output relay if the engine is called upon to accelerate. A top speed tripping circuit is necessary to drop this relay out at full engine speed; however, this fact is not essential to understanding the operation of this system. The principal function of the off-speed channel, as shown in Fig. 12, is to lock the tailpipe variable-area nozzle on engine acceleration at the area that is maintained at the beginning of the acceleration. Lacking such a channel, the nozzle would close upon advancing the thrust selector as shown in Fig. 5. This nozzle locking gives faster accelerations by minimizing the turbine back pressure. A separate effect of the off-speed channel, on tailpipe temperature limit, is as follows:

(1) A transient temperature limit is put on main fuel flow only, during acceleration.

(2) A steady-state temperature limit is put on the nozzle and reheat fuel controls at steady speed or at top speed.

(3) At any time, either the transient or the steady-state tailpipe temperature limit is in operation, not both simultaneously. The off-speed channel works on the temperature reference circuit, to be described later, to select and apply the appropriate limit. The off-speed channel also restricts reheat lighting to top engine speed. The purpose of this is to permit movement of the thrust selector from a reduced speed setting into the reheat region and delay lighting off reheat until the engine has actually reached full speed.

TAILPIPE TEMPERATURE LIMIT GENERATOR

This limit is used in the control system as an amplifier voltage. Fig. 13 shows the manner of its generation. The tailpipe thermocouple (exhaust temperature sensor) voltage is subtracted from a reference. The amplified temperature error signal is the electrical quantity used as a limit. This reference is altered by the off-speed

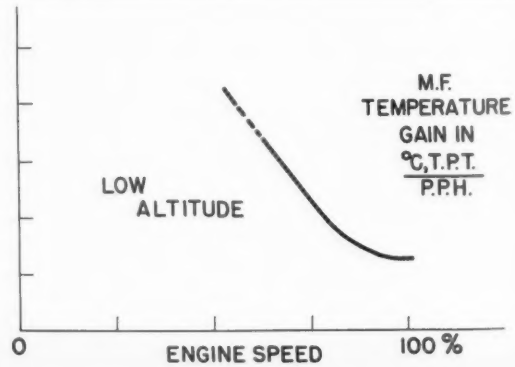


FIG. 17.

channel to provide either steady-state tailpipe temperature limit or the higher transient tailpipe temperature limit, as explained in discussion of the off-speed channel.

Summarizing, then, the control consists of three main servo channels, with overrides provided to keep the engine in a safe operating region: (1) main fuel control, (2) reheat fuel control, and (3) nozzle control. The auxiliary off-speed channel relates these controls, and the overriding temperature limit, to engine speed.

Major Engineering Problems

Engineering a system such as the Integrated Electric Control provides engineering problems that can be grouped in three categories:

(1) Providing adequate system performance over the engine speed and operating altitude ranges required.

(2) Providing component designs that are satisfactory for the ambient conditions that are met.

(3) Providing adequate system and component reliability.

The system performance problems arise from these facts: Basically this system uses servo elements in which the engine is an integral part of the loops. Without going into the matter of servo system analysis, it is certainly true that gain and time constant are extremely important in servo system performance. Roughly, by time constant is meant—how long does it take an element to get moving once it is told to move? It would certainly be expected that in a system that had markedly variable gains and time constants, it would be extremely difficult to get satisfactory performance. This is the crux of a difficult problem in jet-engine control.

Fig. 14 shows the variation in engine gain, measured in speed change per pound per hour of fuel change, over the engine's operating speed range. The variation in engine time constant over this range is also shown. Notice that over the range shown the variation in engine gain is approximately 5 to 1, and the variation in engine time constant is approximately 6 to 1. Fig. 15 also shows significant changes in gain and time constant over a wide altitude range. Fig. 16 shows the variation in thermocouple time constant with altitude at full engine speed. There is also a variation with engine speed which is more severe, over the idle to full speed range. Fig. 17 shows the variation in main fuel temperature gain with engine speed at low altitude. This quantity, as you can see, indicates the sensitivity of the control system to fuel flow from the temperature standpoint. Fig. 18 shows this same main fuel temperature gain as a function of altitude at full engine speed. Actually, of course, in the operation of the engine over a variable speed range, as well as variable altitude range, each of these curves represents but one in a large family of curves which have to be studied.

Fig. 19 shows another type of problem that is encountered in getting satisfactory performance over the altitude range. These curves show the full dry power fuel requirement and the compressor stall limit as a

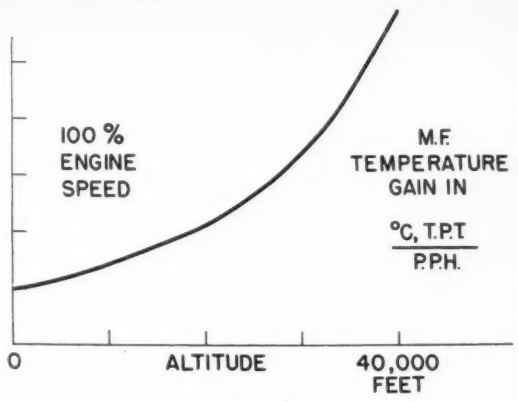


Fig. 18.

function of compressor discharge pressure. These curves might be interpreted roughly as follows: At a given engine speed, decreasing C.D.P. indicates reduced inlet air density and, hence, increasing altitude. The curves then show that the margin of fuel available for acceleration progressively diminishes as the altitude increases. The significance of these curves is this: Good engine operation over the altitude range requires that neither accelerating ability be unduly penalized nor stall or rich burner blowout courted. This requires extreme accuracy in fuel flow setting by the main fuel valve and in compressor discharge pressure sensing.

In the development and design of this control system, various methods were used in working out a design that would satisfactorily handle these performance problems. A study phase was the beginning of the program and represented initial conception of the control. A test program extending over several years has been operated at the General Electric factory. Six months of study and hard work were spent in the NACA Lewis Flight Propulsion Laboratory in Cleveland. This gave some extremely valuable wind-tunnel experience. Controls of the basic engine, without an afterburner, were checked out quite well at Edwards Air Force Base in California, using a modified North American F86A airplane.

Extensive control laboratory work has been done using analog computers. For study, electrical elements of the integrated engine control system are connected

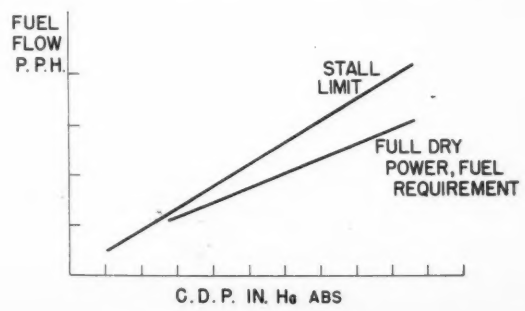


Fig. 19.

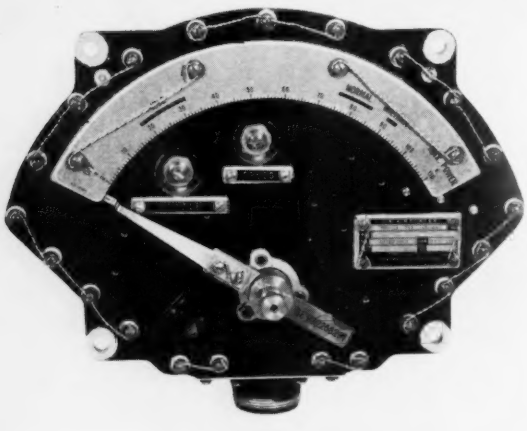


FIG. 20.

FIG. 21.

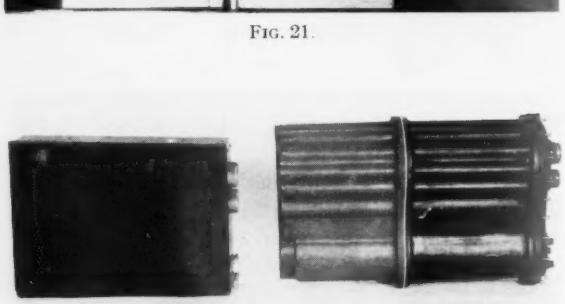


FIG. 22.

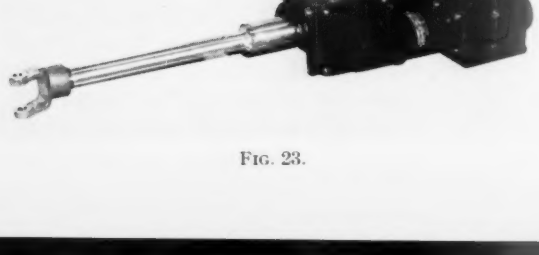


FIG. 23.

to the analog computer. An analog computer is a system that acts like a jet engine, in this particular case. It enables us to complete the loop in the laboratory, without using an engine. This is of considerable value in a quick check-out of new ideas and in running a more complete evaluation of system performance than is sometimes possible using an engine.

A flying laboratory is an important engine and control test facility. This is a modified North American B45 airplane, adapted so that an engine such as the D-17 can be extended from its bomb bay doors. This is an Air Force plane, on bailment to the General Electric Company, which is being operated from the Schenectady, N.Y., airport.

DESIGNING FOR DIFFICULT AMBIENT CONDITIONS

Altitude, temperature, and vibration conditions, under which satisfactory operation must be maintained, put severe requirements on the design of jet-engine control equipment. For each 15,000-ft. altitude change, there is approximately a 2 to 1 change in atmospheric air pressure. The moderately high voltages used in electronic equipment cause a flashover problem to develop rather quickly as altitude is increased. While it may seem that 35,000 and 50,000 ft., both representing high altitude, are not far apart, conditions are actually drastically different for operation of electronic equipment at the higher altitudes. This altitude problem led to the use of pressurized cases on amplifiers in the first production integrated control systems built. Further development work and study led to the use of an open design, which resulted in considerable weight-savings.

A second serious ambient problem is the extreme range of temperatures over which operation is required. A new problem, associated with jet airplane operation, points to higher upper limits being appropriate for jet-powered craft than piston-engined craft. A jet airplane, operating at high speeds, develops high skin temperatures because of the friction of the air stream with the surface of the airplane. At 550 knots, warm-day conditions, and low altitude, skin temperatures approaching 200°F. can be realized. It has been a major problem to find components that will operate satisfactorily under such high temperature conditions. Capacitors, resistors, wire, and transformers all require special treatment.

A third serious problem arises in building equipment that is sturdy enough to do the job. Despite the smoothness of jet airplane operation, harmonics of the engine fundamental frequencies have to be sustained on engine-mounted equipment, and high maneuvering acceleration forces have to be handled. Compromises in size and weight frequently have to be made in order to get equipment that is rugged enough to do the job.

RELIABILITY

In the design of a system such as this having many components, reliable operation requires the utmost in

dependability of each individual component. The reliability problem is a serious matter; constant attention is required to it, and it frequently seems that long periods elapse before such efforts pay off. General Electric methods of maintaining and improving reliability are as follows: (1) careful quality maintenance work, (2) shakedown of equipment on bench and engine test prior to shipment, and (3) active participation in such extensive operations as the Arinc program for better electron tubes. Ruggedized tubes have been introduced into the amplifiers as rapidly as they become available.

Reliable system operation also imposes certain requirements on the airplane and on the airplane-mounted equipment. System performance is dependent on dependable electric power supplies. It is vital that the wiring that ties together the engine control components be carefully designed. Since system components are mounted on both the engine and the airplane, this is a problem that the engine manufacturer shares with the airplane manufacturer. Particular attention is required in:

(1) Careful wiring and arrangement of AN connectors to allow frequent mating and unmating without damage to circuits during maintenance operations.

(2) Layout of wiring to minimize chances of damage while the airplane is being serviced and maintained.

Fail-Safe Philosophy

In the design of a system embodying many elements working together, it is necessary to give careful consideration to the consequences of component failure on system performance. It is desirable to lock the control system where it was at the time of failure, when a failure occurs. This, however, can be done only for the more likely failures. For example, a tube circuit can be designed so that opening of the heater will not result in a control element's moving. If a tube fails, it is likely that the failure will be a heater opening. However, the same means of protection may not do the job in the event of a cathode to grid failure or a cathode to plate failure of a multielement tube. Basically, the effort has been to provide safe operation in case of a single failure. A multiple failure problem becomes much more complex, because the possible combinations are tremendous. In this integrated control system, certain means have been established to give the pilot a quick corrective procedure in case of a control system failure:

(1) A separate emergency fuel system, not described here, is provided in case of main fuel control failure in the automatic system.

(2) The pilot can jog the nozzle open or shut at any time.

Studies are continuing on the failure problem. In any system involving numerous elements, the failure problem is a knotty one.

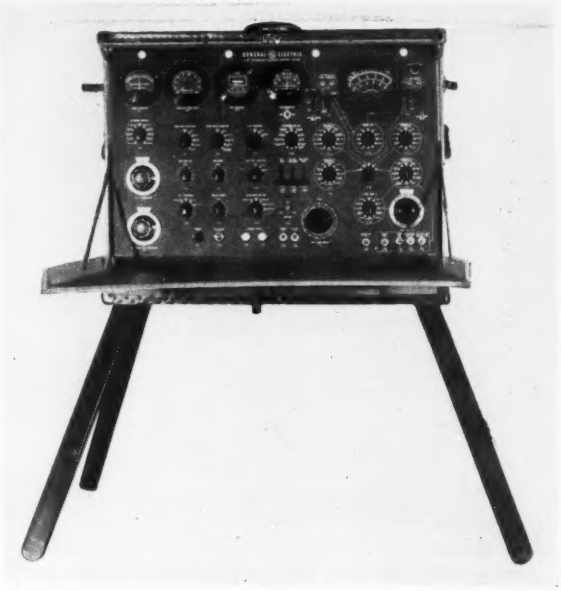


Fig. 24.

Major Components

Fig. 20 shows the thrust selector. As previously mentioned, this is the pilot's input to the control. It represents his "single control lever." This element is air-frame mounted and is linked to the pilot's throttle quadrant.

The electronic equipment required in the control system is housed in two chassis. They are air-frame mounted. Fig. 21 shows a set of the early production pressurized amplifiers mounted in a jig for engine testing. It was previously pointed out that this pressurization was initially necessary to cope with the altitude problem. Fig. 22 shows a closed, or pressurized, amplifier as compared with the later open amplifier design. The later design, made possible by study and development, affords an appreciable saving in size and weight. Shock mounts required for the amplifier installation are not shown.

Fig. 23 is a picture of the jet nozzle actuator. The actuator involves a d.c. motor that is geared to a jack screw. The linear output motion is transmitted to the afterburner variable-area nozzle lids. This actuator is run normally from the engine-driven amplidyne. Emergency operation off the airplane's d.c. bus is provided.

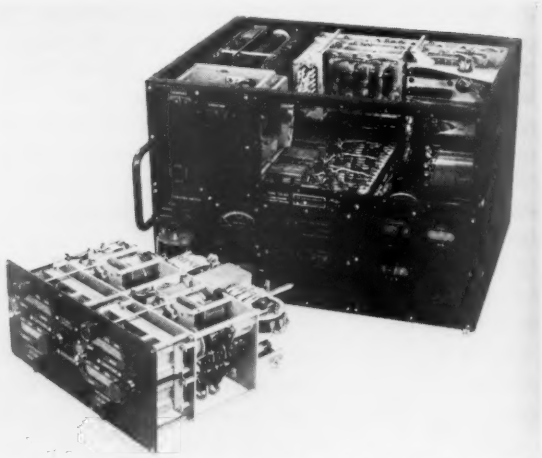
The J47-17 integrated control system represented a pioneering step in the application of electricity and electronics to engine control. Uncertainty as to just what the system requirements were, plus the difficult ambient conditions that had to be met, have resulted in a design that is somewhat heavier than was initially expected. Careful study is being given to the weight problem. An important example of the fruits of such study has been the change from the closed design amplifiers to the opened design, which represents a 50 per cent weight reduction in amplifiers.

(*Continued on page 73*)

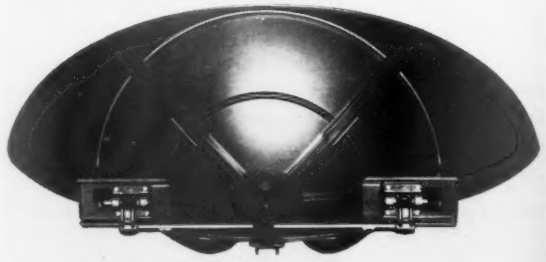
Some Recent Developments

(*Continued from page 58*)

Most powerful air-borne radar ever built, manufactured by the General Electric Company at Utica, N.Y., is carried by this new Lockheed long-range, high-altitude reconnaissance scout. Radar antennas are mounted inside radomes, atop and below the aircraft's fuselage. Both the Navy and Air Force will use the giant planes as radar stations to fly off our Atlantic and Pacific coasts and to supplement the "radar fence," now guarding the U.S. and Canada against sneak enemy air attack.



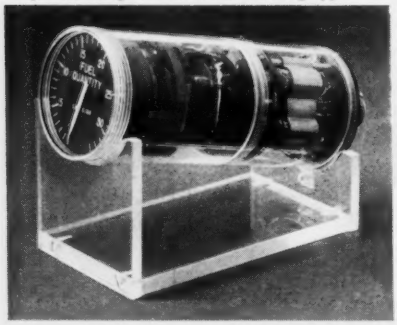
Designed to operate in conjunction with air-borne radar, this Ground Position Computer, produced by Eclipse-Pioneer, provides visual steering and timing information for navigation.



Large 8-ft. search radar reflectors of this type, carried in the Navy's antisubmarine patrol planes, are constructed of magnesium by Brooks & Perkins, Inc.

The Liquidometer Corporation's fuel gaging system consists of a standard capacitor-type gage and a small panel-mounted selector switch, which offers a dual indication of fuel remaining—either gravimetric or volumetric.

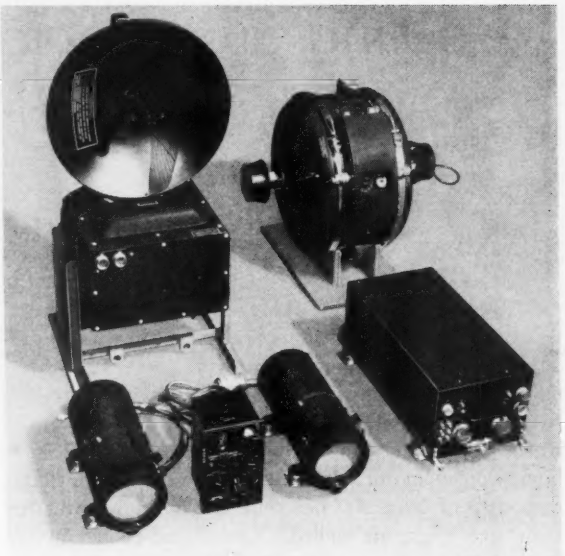
A new indicator-amplifier fuel gage system, developed by Simmonds Aerocessories, Inc., incorporates both the dial indicator (giving a reading of fuel quantity as measured in pounds) and the amplifier bridge of the self-balancing type.



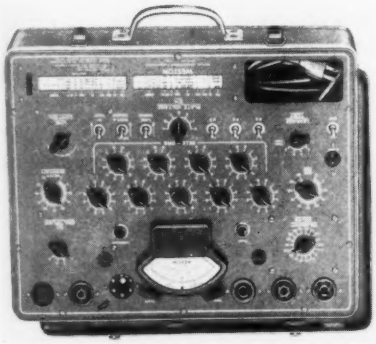
Recently added to the Bendix Aviation Corporation Red Bank Division line of tubes is this new full-wave, high-vacuum rectifier type that employs a cathode-type structure with extruded ceramic heater insulator and a coil-type heater instead of a filament structure.

This saturable reactor is the heart of a new magnetic amplifier developed by Airborne Accessories Corporation for artificial "feel" systems in powered flight control. Using no delicate or moving parts, it features a high degree of reliability and helps keep the pilot from overcontrolling his plane.

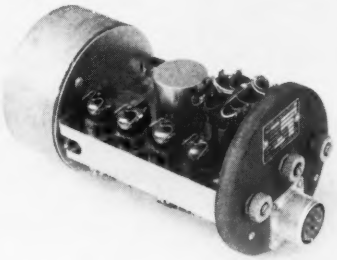
Three hundred and sixty-five vacuum tubes are employed in this radar-optical K-system bombsight, developed by Sperry Gyroscope Company and currently used in many long-range USAF bombers.



Designed by Bendix-Pacific for the Air Force, this lightweight radar set provides visual indication of the position of other aircraft, cloud formations, landmarks, cities, shorelines, etc.



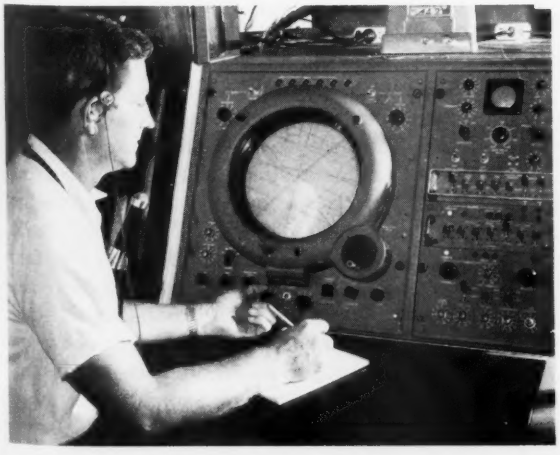
Weston's portable Tubechecker, with roll chart with complete up-to-date data for testing all tubes, provides accurate meter measurement of leakage resistance as high as 5 megohms between tube elements.

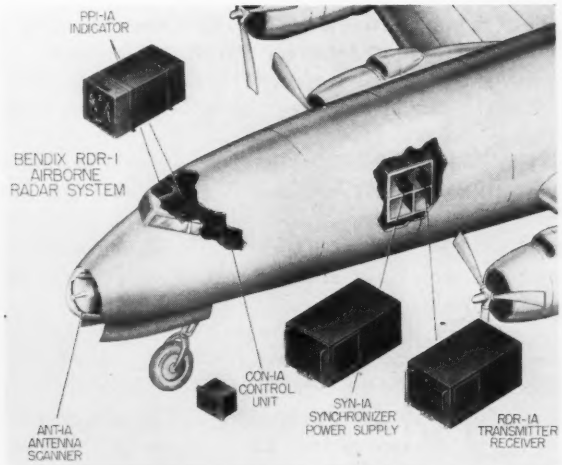


A single-axis flight control instrument, produced by LearCal, operates automatically to dampen the tendency of an airplane to oscillate about the yaw axis.

This remote control unit is a part of one of the complete radio compass systems, manufactured by Lear, for private and military aircraft.

General Electric Company's new surveillance radar system shows the traffic controller the location and flight path of every aircraft flying within the 30- to 60-mile radius of the airport and assists him in directing each plane via radio through a safe and efficient traffic pattern.





The vital need for practical air-borne radar for air-line use led to the development by Bendix Radio Division of the system and typical installation shown here.

(*Continued on page 80*)

Cooling Supersonic Electronic Equipment

DOYLE C. WELLS*
Ryan Aeronautical Company

IN THE PAST YEAR, work on liquid cooling systems and associated components has been undertaken at the Ryan Aeronautical Company for the purpose of determining how they may be applied to subminiaturized electronic equipment, microwave power tubes, and electric motors and generators. In general, subminiaturized equipment with power densities as high as 2 watts per cu.in. can be cooled with liquid. Small liquid-cooled motors of the a.c. type can be run continuously at over 200 per cent the normal power for their size when air cooled. One liquid-cooled motor produced a continuous output power of 35 watts while an air-cooled continuously operating motor produced 17 watts and was about 30 per cent larger. A microwave transmitter tube with a dissipation of over 50 watts per sq.in. has been cooled with a liquid system. In this system, the liquid velocity was purposely kept low to avoid microphonic tube noise. A small centrifugal pump driven by a three-phase, 400-cycle motor drawing 30 va. was used to circulate the coolant through the tube and associated temperature regulation channels.

The liquid used in most cases was triethylene glycol and was chosen for its high specific heat, high density, low freezing point, and low vapor pressure that permits operation at 50,000 ft. altitude without pressurization. This liquid has a high viscosity at low temperatures, necessitating a careful consideration of pump design in all respects. In general, pump clearances are made large, fewer guidance vanes are necessary, and high velocities are avoided. As a rule, pumps with 40 to 50 per cent efficiency are possible with this viscous liquid if extreme care is taken in their design. As a rough rule of thumb, it takes about 5 watts of electrical energy at the pump input for every 100 watts of heat to be removed by the cooling system. This figure may vary twofold depending on the specific requirement of a cooling system.

The cooling environment imposed on a piece of equipment by an aircraft of a few years ago was not far different than the environment of a ground- or sea-based vehicle. Today, in contrast, the cooling environment has changed drastically because of higher speeds and altitudes.

Cooling in the past has been done by passing air over and through the equipments. This air was taken from the outside of the airplane through ram air intakes. The air in the intakes was sped up from zero to almost the aircraft speed and thus was compressed by virtue of its momentum change. The air temperature increased along with the pressure rise. In slow aircraft, this temperature rise was not troublesome although it had to be taken into account. The general relationship for pressure rise versus air density, velocity, Mach Number, and specific heat ratio is

$$\Delta P = \frac{Pv^2}{2g}\left(1 + \frac{1}{4}M^2 + \frac{2 - Y}{24}M^4 + \ldots\right)$$

At low speeds, the pressure rise is only slightly above $Pv^2/2g$. At Mach 1, the pressure rise will be roughly one quarter more than would be indicated if the relationship neglecting compressibility were used. Since the temperature goes hand-in-hand with the pressure, one can see that the temperature of ram air will rise to intolerable values at around Mach 1. Since the ram temperature is directly proportional to air density, the ram rise will be lower at high altitudes. This effect, however, is cancelled out in any heat exchange system because the heat transfer coefficient is also proportional to the air density.

The situation at Mach 1 and above, then, can be summed up as follows: (1) Any air taken from the outside will be too hot to use in its present condition of temperature. (2) Air inside the aircraft will also be too hot to use after steady-state conditions are reached.

Present-day aircraft are handling the situation in two ways: (1) Air cycle refrigeration is used to reduce the air temperature. (2) The equipment is built to withstand the increased temperature. The first method has limitations at speeds above Mach 1 because of high power consumption. The second method, while theoretically the better of the two, has not been attained in electronic circuits. Transformers, relays, magnetic components, in general, can meet the present temperature demands while condensers, transistors, crystal diodes, and precision resistors cannot. There is little or no hope of this second method keeping pace with aircraft speeds.

The solution to the problem is a cooling system that is independent of aircraft speed and altitude. Any system that is independent of speed and altitude cannot use atmospheric air as a direct heat-transfer medium or heat sink. This means that either the heat must be stored in the aircraft for ejection at a later time, or it must be ejected from the aircraft in flight. The first can be accomplished by allowing the heat to increase the temperature of a high specific heat material and dissipating the heat at lower altitudes and speeds or on the ground after the flight. This amounts to nothing more than a time lag system and is applicable only to short flights and low power dissipations.

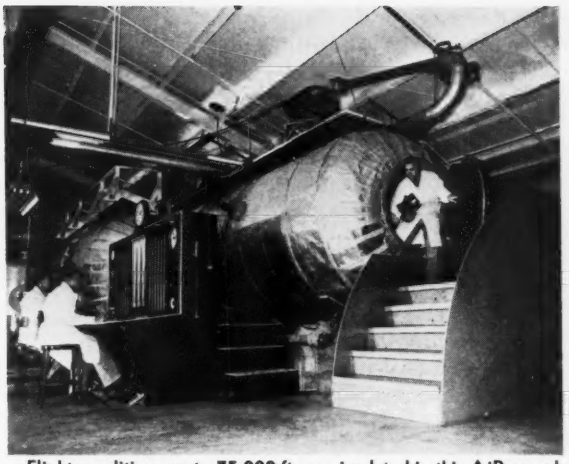
* Electronics Engineer.

The latter can be accomplished in several ways: (1) The fuel used by the aircraft could be used as a coolant before it is burned in the engine. (2) A solid could be sublimed in the presence of a liquid coolant. In this case, the gaseous products of the sublimation are piped overboard. (3) A liquid could be made to boil in a heat exchanger or in passages in the equipment, thus absorbing heat. The gas would either be piped overboard or expanded for further cooling advantages if altitude permitted.

Fuel cooling has many possibilities. The specific heat of jet fuel is about 0.6 calorie per gram and its density is about three quarters that of water. Its effectiveness in a heat exchanger can be seen to be approximately half that of water. The flow rate in a jet engine of 10,000 lbs. thrust at cruising speed would amount to some 30 gal. per min. One can compute that, for each degree centigrade rise in fuel temperature, 2.5 kw. of energy could be absorbed by the fuel. The magnitude of the allowable temperature rise of the fuel is not large, but it need not be large as shown by the following example. Taking the specific heat as 0.6 calorie per degree centigrade and a temperature rise of 20° to 30°C., it is evident that 50 or 75 kw. of heat could be dissipated. This is more than ample for any electronics combination in aircraft today.

The sublimation of a solid does not offer as much on a weight-for-weight basis as either of the other two systems. Solid refrigerants, while easy to use and acquire for experimental setups, are just the opposite for combat planes. By necessity, the solid refrigerant must be manufactured at its locality of use. This would not be practical, for the quantities needed would be large and the machinery to produce it bulky and heavy.

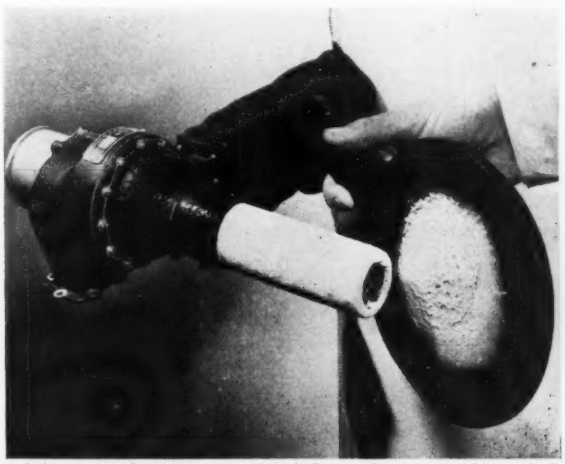
The boiling of a liquid has moderate possibilities as a heat sink. There are many liquids that could be used. However, none compare to water for latent heat, density, and availability. The latent heat of water is about 600 calories per gram when starting from ground temperature. This means that 1 gram of water in boiling will take with it some odd 2.5 kw. sec. of power. As an example, suppose a radar system of 1-kw. dissipation is to be cooled. Water with a suitable antifreeze is stored in a tank as close as possible to the equipment to be cooled. A small centrifugal pump requiring about 50 watts input power would force the water through thin-wall tubing brazed to the chassis of conduction-cooled equipment or through heat exchangers in pressurized equipment. The water and steam mixture then returns to the storage tank. The amount of water evaporated will be 3 or 4 lbs. per hour. This quantity amounts to less than 2 quarts. Since the flight time of a fighter capable of traveling at supersonic speed would be a little more than 1 hour, a cooling system with a moderate heat load using a water antifreeze solution as its heat sink could be used This system would be compact, light in weight, require little power, and have maximum simplicity.



Flight conditions up to 75,000 ft. are simulated in this AiResearch Stratolab chamber to test heat-transfer cooling equipment for aircraft.

Equipment designed to use a heat sink such as this should preferably work about 100°C. However, systems can easily be made to run as low as 80°C. Such a system would incorporate a centrifugal blower to produce a vacuum on the heat sink at low altitudes. This blower would have to have speed control if a constant temperature in the heat sink were desired. Otherwise, it could be left free to run until a preset altitude was reached, then shut off. A spring-loaded bypass valve could regulate the temperature at all higher altitudes. In most cases, the heat inertia of the liquid would be adequate to keep the temperature of the system below the maximum boiling temperature until the airplane climbed above the minimum altitude needed to maintain this boiling temperature equilibrium. Each specific system would have details that would have to be worked out with cognizance of the equipment to be cooled.

In certain equipments, an inert liquid or gas under pressure is necessary for high voltage insulation be-



Like a tornado in a teapot, this AiResearch midget turbine whirls at a furious 100,000 r.p.m. to provide frosty air for cooling subsonic aircraft such as the Lockheed F-80 Shooting Star.

tween wires and components. Transferring the heat developed in the equipment to the heat sink via this liquid or gas is a problem requiring much study and careful design. The basic problem is one of forced convection.

In forced convection, heat is transferred from a surface to a liquid or gas according to the relationship.

$$Q = hA\Delta T$$

where

Q = quantity of heat
h = local heat-transfer coefficient
A = area of surface
ΔT = temperature difference between fluid and surface

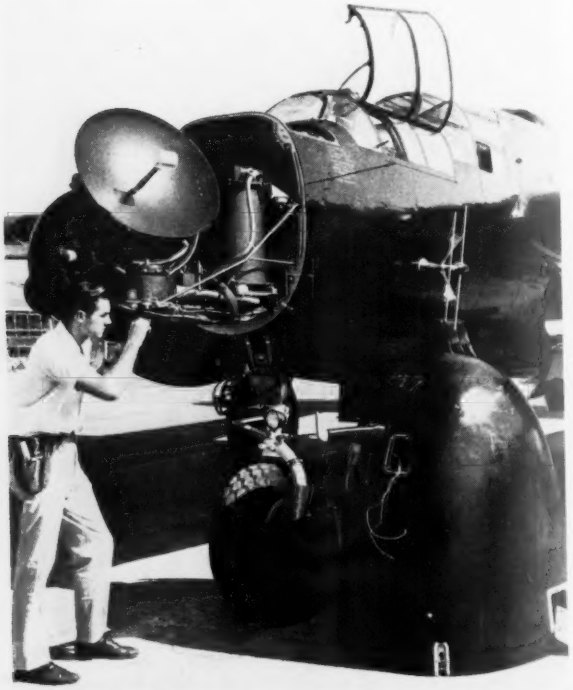
The heat-transfer coefficient is usually found specifically by experiment; however, it can be found approximately with a relationship due to Reynolds.

$$h = C_f C_p P v/2$$

where

h = heat-transfer coefficient
C_f = friction factor
C_p = specific heat of fluid
P = density of fluid
v = velocity of fluid in main stream

This relationship is as true when the Prandtl Number is near unity as it is for air and water at the temperatures to be used for electronic equipment. For other liquids, such as insulating oils, a correction factor must be applied. Friction factor data show that C_f is proportional to Reynolds Number and surface roughness. It can be seen that high heat-transfer coefficients can only be had at the expense of pressure drop since h is directly proportional to C_f. Pressure drop when using air as a heat-transfer agent is usually limited to several inches of water or approximately 0.1 lb. per sq.in. This limit is imposed by available blower sizes and speeds. Small centrifugal liquid pumps, however, can operate efficiently at slow speeds and produce pressures of the order of 5 lbs. per sq.in.



Typical of the electronic equipment that is adding heat to the aircraft of today is this electronic "eye," or radar scanning antenna, used in the Northrop F-61 night fighter.

In supersonic aircraft, such as this North American F-100 Super Sabre, methods for cooling equipment must be independent of outside air.

Let us compare two similar systems—one using air, the other water—consisting of a piece of equipment dissipating 1 kw. connected with ducts to a heat exchanger. The allowable temperature rise of the cooling medium on passing through the heat exchanger will be 10°C. The pump motor in both cases will have the same power, roughly $^1/_8$ hp. The volume of flow necessary for air is found to be 175 cu.ft. per min., while for water it is 0.05 cu.ft. per min. This large difference is due mainly to the volume density difference between water and air and secondarily to specific heat differences.

The pump pressures would be 0.1 lb. per sq.in. for the air blower and 5 lbs. per sq.in. for the liquid pump. With these pressures available, the velocities in the heat exchangers would approach 110 ft. per sec. for air and 27 ft. per sec. for water. Reynolds Number would be 1×10^5 for air and for water 3×10^3. These values of Reynolds Number yield friction factors of 0.006 for air and 0.06 for water. The heat transfer coefficients using the Reynolds equation for air would be approximately 0.10 watt per sq.in. per sec. and for water 600 watts per sq.in. per sec. The areas in the two respective heat exchangers thus would have a ratio of some 6,000 to 1. The ducts connecting the equipment to the heat exchanger will be about 3 in. in diameter for air and $^1/_2$ in. in diameter for water. The system using water then is much more compact than the air system. When comparing relative weights of the two systems,

one must consider the medium on the other side of the heat exchanger. If air is used as the medium of the heat sink, the heat exchanger would be large, and the liquid heat transfer system will be the heavier. If a boiling liquid or fuel were used as the heat sink, the opposite would be true. Neither of these two systems is of practical value, but they were presented to show the tremendous difference between air and liquid systems.

In the future, when aircraft speeds progress well past transonic speed and when altitudes of 15 miles are commonplace, not only electronic equipment but hydraulic and rotating electrical machinery will also have to be cooled by means other than air. It would appear that fuel would be the best choice for an integrated aircraft cooling system heat sink, although liquid evaporation will find its place for small isolated pieces of equipment.

Integrated Electric Control for the General Electric J47-17 Jet Engine

(*Continued from page 67*)

Field Service Provisions

In a system of this nature, it is extremely important that means be provided for a quick system check-out. The most helpful thing in keeping down-time to a minimum is to be able to determine quickly which element specifically is at fault. Development and design of the integrated control system has also included the design of the Field Tester. (See Fig. 24.)

The Field Tester is a portable system analyzer, which can be plugged into the airplane wiring and can simulate operation of all electrical channels. Individual amplifiers can also be checked by using slave components for the rest of the system. A carefully designed procedure has been established to make the tester suitable for use by relatively inexperienced personnel. Working out this procedure represented an appreciable engineering effort.

Recapitulating in conclusion, a brief description of the engine to be controlled has been presented. The philosophy and methods of the Integrated Electric Control have been discussed. This is definitely a pioneering step in engine control. Many ways are open for improvement. We all know that the automobiles of today are not much like those of 40 years ago. The most significant thing about this control system is: It is truly an integrated control, tying together all functions of the main engine, variable-area nozzle, and the afterburner.

Keep Posted on New Aircraft Products and Product Literature

Make it a habit to check the *Aeronautical Engineering Review's* "New Products Section" every month. Located at the end of each issue, it contains a complete review of all recently announced new product developments and product literature of special interest to the aeronautical profession. Handy tear-out postals are included for your convenience in requesting additional information direct from the manufacturers.

Make It a Habit—Use the "New Products Section" Every Month

AERONAUTICAL ENGINEERING REVIEW

The Role to Be Played by

Training Devices in the Training of Aviation Personnel

EDMUND O. CARMODY*

Stanley Aviation Corporation

(I) Origin

The origin of "synthetic training" on a national scale dates back to the pre-World War II era beginning with Adolph Hitler's rise to power. Hitler had a specific blueprint of his plan, one of the first steps of which was the undertaking of the military training of large numbers of troops in weapons and tactics without the use of those weapons. Stripped of all armament by the Treaty of Versailles and realizing that the rest of the world would be content to sit idly by for a few more years, Hitler embarked upon a program of military training which was heretofore unknown in times of peace. You may recall that his wooden mock-ups of guns and dummy tanks built upon bicycle frames were labeled Hitler's "Pseudo-Wehrmacht." However, his blueprint unfolded itself rapidly with the scrapping of the Versailles treaty, when large quantities of weapons began rolling forth from his factories, and the wooden guns and tanks were replaced by those of steel. The tactics and lessons learned on the wooden weapons were immediately applicable to warfare, and, as soon as the weapons were available in sufficient quantities, he was on the march and synthetic training had paid off handsomely.

Great Britain, alert to the training task that had been accomplished by Germany in a remarkably short time, began an evaluation of this new concept known as synthetic training. She realized that air power would be a determining factor and accordingly increased aircraft production, then turned to the task of training the greatest possible number of air crewmen in the shortest time. To do this, she employed synthetic training along a more specific and scientific line. The British Air Training Command began the training of flight personnel even before the actual aircraft were available to carry crews aloft. Here again, the employment of synthetic training was dictated by necessity and made possible the training of the greatest number of aviation personnel. As Germany relentlessly bombed England, forcing her to shift the Empire flight training to Canada, England pressed the development of "Special Devices." With the loss of control of the air spaces above her, training in the air became unprofitable, so bombardiers and navigators found themselves laboring behind odd contraptions that duplicated the operational conditions. As the British continually explored the potential of synthetic methods and equipment, it became increasingly evident that greater returns could be achieved through the employment of scientifically planned "Training Devices," and to this end they put their energies. They fully understood that synthetic methods and equipment could not replace actual flying or combat experience, but the use of devices would serve to prepare combat crews while simultaneously releasing aircraft for combat use. Britain needed every man and piece of flying equipment which she could put into the air. Hence, the art of synthetic training and the application of special devices were increasingly employed. The pay-off came with the Battle of Britain where it was

Fig. 1. Link B-47 flight simulator.

Presented at the Electronics Session, Twenty-Second Annual Meeting, IAS, New York, January 25–29, 1954.

* Contracts and Sales Manager.

proved beyond a doubt that the devices were not "toys and gadgets" but rather their use had saved Britain time, money, and lives.

The United States' interest in special devices was evidenced by the funds that were made available to the Navy Special Devices Section. In the beginning of 1942 it had available $1,000,000. Three months later this had been supplemented by an additional $10,000,000, and before the end of the year funds available for special devices stood at $36,000,000. This was a substantial amount of money for an idea so new to this country.

The war record of training devices is an outstanding one and a monument to the foresight and energy of that small group who pumped an ever increasing flow of training aids into all parts of the allied world throughout the war. Significant are these statements from a War Department press release of April 4, 1946:

"At least 524 lives, $129,613,105, and 30,692,263 man-hours were saved in one year, through Army Air Forces' use of 11 Synthetic Training Devices, according to a survey conducted for the AAF by independent research analysts. The survey report, recently declassified and made available for publication, also stated that use of these 11 Devices actually freed 15,043 men for other military duties and 'it appears clear that Synthetic Training Devices, as a group, have been of tremendous value to the AAF training program during the war period.'

"Measurable advantages, in both war and peace, according to the report, include lives and money saved. Other advantages, immeasurable but conclusive, include improvement of the quality of training and facilitation of crew proficiency maintenance. Strictly wartime advantages include time saved—translated into (a) more men trained per month; (b) men freed for other military duties; and (c) improvement in skill of graduates taking courses unchanged in length—and release of critical equipment and supplies, especially in times when it was almost a case of—*no trainers, no training.*"

Another example of savings made by the use of synthetic training devices during World War II is afforded by statistics revealed at a hearing before the subcommittee of the committee on appropriations of the House of Representatives in 1947: "Nineteen typical Special Devices were estimated to have had a potential total savings of $1,241,281,400 in *one* year." Thus, the war record of training devices stands as indisputable testimony to the potential it holds in the field of personnel training.

The postwar period saw another kind of progress in this new field when emphasis was shifted from quantity to quality, where research and fidelity of simulation became the goals. The world thirsted for speed, and, as the jet engine replaced the reciprocating engine, it became evident that, whereas the trainers had always followed *after* the equipment they simulated, their greatest value could be realized *if* they arrived for

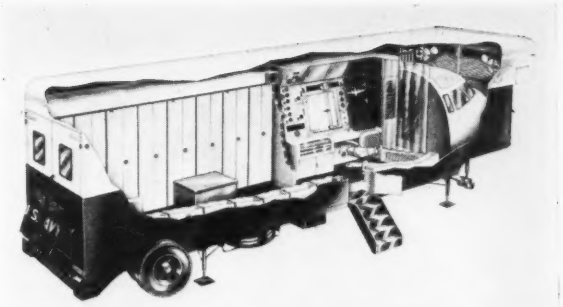


FIG. 2. Engineering Research Corporation's P2V-5 "Neptune" mobile operational flight trainer.

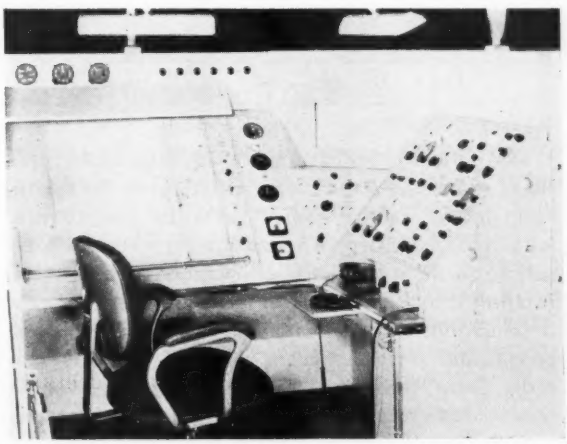


FIG. 3. A close-up of the Link C-11 instructor's station.

personnel training *in advance* of the operational equipment.

Up to this point, training devices primarily relied upon mechanical or electrical systems for resolution of characteristics, and actuation was, for the most part, pneumatic, electrical, and mechanical.

But the application of electronic computers and servomechanism principles to training devices permitted duplication of numerous high-speed characteristics and nonlinear responses. As those responsible for training clamored for more duplication and greater fidelity, industry labored to satisfy while concurrently introducing miniaturization, improved environmental features, new navigational systems, and more accurate instrumentation.

(II) PRESENT STATE OF THE ART

Today in aviation, training devices are being employed extensively to train pilots, air crews, instructors, antiaircraft gunners, technicians, and a host of support personnel in such subjects as Flight, Navigation, Power Plants, Gunnery, Radar, Bombing, Recognition, Fuel Management, and Weather. Evidence of this extensive employment is to be found in the monies that have been spent over the past few years for devices. From the Record of Congress we learn that the Air Force alone has spent over $243,000,000 for major training devices since 1951.

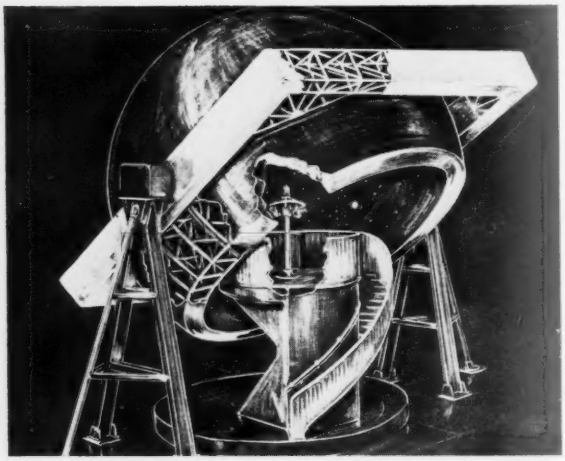


FIG. 4. Link high-speed navigation trainer.

The present "state of the art" is best exemplified in the flight simulator, so let us review its place in aviation training and examine what it can do for the instructor who is charged with pilot and/or crew training. By definition, the flight simulator, or operational flight trainer, is required to reproduce faithfully the airplane's cockpit and instrument responses to movement of the controls, levers, and switches. This, you will agree, is a big order, but, when successfully achieved, the training potential is great, as indicated by the following areas of training in which the flight simulator can be used:

(1) *Cockpit Familiarization*—the location and juxtaposition of all instruments, knobs, controls, and switches.

(2) *Engine Operation*—the effects of thrust and torque.

(3) *Flight Characteristics*—normal and high speed at altitude and in heavy weather conditions.

(4) *Systems Familiarization*—hydraulic, electrical, instruments, and electronics.

(5) *Navigation, Gunnery, and Bombing Training*—including radio and radar.

(6) *Fuel Management*—requiring selection of best altitude and throttle setting.

(7) *Procedure Practice*—(a) normal, such as before starting engines, night take-off, and instrument let-down; (b) malfunction practice, proper corrective action can obviate an emergency; and (c) emergency practice and test, covering engine, flight, and fuel systems.

(8) *Simulation of the Mission.*

All these areas can be brought to focus by the instructor for use in: (1) initial pilot and crew training, (2) refresher training, and (3) transition of experienced flight teams to new types of aircraft.

From this you can appreciate the wide application of the simulator to the training problem. Now let us examine the electronic flight simulator. Link's B-47 simulator is shown in Fig. 1, and Engineering Research Corporation's P2V–5 mobile operational flight trainer is shown in Fig. 2. Simulators are comprised of these major interrelated systems: (1) engine, (2) flight, (3) navigation, and (4) gunnery, and these principal components: (1) cockpit area, (2) computer cabinets, and (3) instructor's station.

Next, let us review the facilities that are available to the instructor for teaching, for practice, and for examination of his student pilot and crew. First, remember that the very problem itself is intricate because of its nature and variables; then too, the instructor must draw out of his student by the introduction of subsequent factors—demonstrated skills—all of this before the pilot will be entrusted with, say, a B-52 jet bomber expected to cost 5 millions. To assist him, the instructor has a station, such as that shown in Fig. 3, which is comprised of the following parts:

(1) *The Recorder*—which shows the exact geographical location of the airplane regardless of whatever wind velocities have been cranked in.

(2) *Monitoring Instruments*—so he can see what the student sees in the cockpit.

(3) *Telltale Lights*—which register not only proper engine and airplane functions but errors in procedure and technique.

(4) *Malfunctioning and Emergency Switches*—for introducing additional problems. A punctured gas tank or engine fire requires immediate decisions and may call for a change in the flight plan.

(5) *Scoring and Recording Equipment*—for grading and permanent record. Thus, at the critique, fact replaces opinion.

There is also other equipment that is capable of training 24 hours a day, regardless of the weather, and is not affected by availability of operational equipment (see Figs. 4–8).

In the design of the flight simulator and its companion devices now in use in numerous training areas, the makers of electronic training equipment have done an outstanding job, and to them we offer heartfelt and well-deserved congratulations. But just as the race for speed has brought new problems to the air-frame manufacturer, so has the simulation of that high performance brought concomitant problems to the electronic designer. Thus, the increasing high costs of training equipment, the early obsolescence and difficulties of maintenance become definite *limitations*

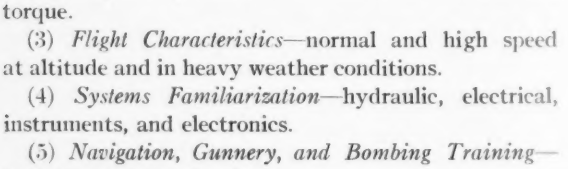


FIG. 5. Erco carrier landing trainer (view A).

to more extensive use, *unless* planners and designers of new equipment are able to combat successfully these factors.

What, then, are some of the *means* whereby these *limitations* that apply to all training devices can be lifted in order to permit a steady flow of required training equipment from the planners, through the manufacturers, to the users? Three ways in which this can be done are:

(1) Production will assist in reduction of costs, but, *if* training devices are to continue to assume an ever increasingly important role, production must be paced well in advance by research—research by training specialists and human engineers who tell the designer what *kind of characteristics* are important to simulate and the degree of simulation required. These two factors are important for they determine the cost of the trainer and level of maintenance.

(2) Research is also required by electronic engineers to:

(a) *Effect standardization of components:* Production runs of standardized components would result in decreased cost, aid the support and supply problem, and allow interchange between trainers of different manufacturers.

(b) *Improve the present computer or design a new computer or develop a method for adapting the digital computer to simulator work:* This would in turn readily permit one computer to be changed from providing the characteristics of one type aircraft to that of another type. Reuse of computers by adaptability to later types of aircraft would result in considerable savings through the elimination of early obsolescence.

(c) *Incorporate transistors into the design:* Besides reducing cost, this would be another step toward production miniaturization with its concurrent advantages of smaller required space and ease of mobility.

(3) Continued analysis of the methods of device utilization for the purpose of determining the following:

(a) *The best device or combination of devices to assist in the training task:* Here the trainer potential must be weighed against cost. For example, the Air Force is currently investigating, through procurement, a series of low-cost procedure trainers that will be capable of performing part of the training now carried out in flight simulators. These new trainers will teach cockpit familiarization, engine indoctrination, and normal and emergency procedures—thus freeing the flight simulator of these areas of training and making more simulator time available for final checking and simulation of the total mission, which only it can give. Hence, through a *combination* of a procedure trainer and flight simulator, it is possible to reduce the per student trainer cost or, conversely, to increase the student flow without increasing the number of simulators. The procedure trainer will also serve a most useful purpose for training where no flight simulator will be available.

(b) *That adequate utilization manuals should accompany the device into the field:* This publication tells the instructor what can be taught with the trainer and how to get the most out of the trainer.

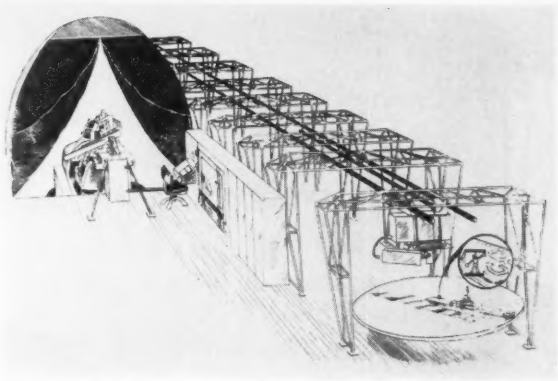


FIG. 6. Erco carrier landing trainer (view B).

(c) *That instructors receive proper initial training on the use of devices and refresher training whenever required by receipt of supplementary equipment or changes in procedure:* Whenever possible, the same operator should be used on the training device and operational equipment.

These are some of the means that must come to pass in the planning, designing, and utilization stages of training devices if the limitations of cost, obsolescence, and high maintenance are to be overcome.

(III) The Application of Training Devices to Future Weapons and Tactics

Before developing this next topic, I would like to point out several significant facts and conditions in which, for one reason or another, the latest weapons may be brought into use. These facts and conditions are not only pertinent to our survival but raise the question as to the adequacy of current training methods. They are:

(1) America's protective oceans in the past have served as isolation barriers to those who would invade our country. Today, foreign transonic jet bombers refuelling in flight can fly over the Pole to deliver swift

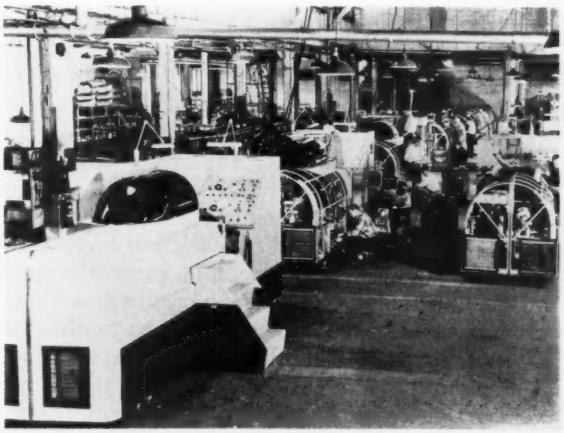


FIG. 7. Link C-11 trainer production.

FIG. 8. Link E-26 gunnery trainer.

destruction to our vital population and production centers.

(2) In the last two wars, our allies provided the "time" for us to train our forces and build up production lines. We will not be permitted this luxury in the event of another World War.

(3) In World War I and II, man had not yet developed the capability of annihilating himself with his weapons. Germany relentlessly bombed Britain, but aided and supported by her allies, England lived and grew stronger. Today no nation can continue to fight under repeated H-bombing attacks.

(4) In previous wars, we entered the engagements as a third, fourth, or even fifth strongest power. Today we are the buttress of the *free* world's defense, providing leadership, assistance, and support to the family of free nations.

(5) In the past, when new weapons such as tanks, rockets, and airplanes were developed to the operational stage, they were turned over to the Armed Forces for training and integration wherever applicable. Today, when the latest weapons—atomic, bacteriological, and chemical—can be used against our centers of production and population with devastating effects, conventional methods of personnel training may not be adequate because of the special problems inherent in the employment of these new weapons. Therefore, training will be required in both defense and offense. To prepare for this, highly specialized training by a limited number in the Armed Forces and generalized training in survival by millions will be required.

These five conditions call for an entirely new set of ground rules. The question is: Should we continue to apply conventional solutions in a game where the rules have so drastically changed? The answer is obviously "no" if we expect to survive. What, then, is our best approach? Modern weapons will first go through a period of test and evaluation which will involve the training of relatively small groups, the purpose being to ascertain the applications, limitations, best methods, and tactical use of the weapons. This we can label as Phase I and is illustrated by the recent tests carried out at Frenchman Flats in Nevada. Phase II of the program will consist of a transfer of that knowledge and methods learned in Phase I to the Armed Forces and whatever portions of the civilian population which are deemed essential to an all-out effort.

The nonfeasibility and economics of the situation may prohibit the use of H-bombs, nerve gas, and germ warfare to train in the proper numbers in Phase II, yet this training must be accomplished if we are to survive. Therefore, this will have to be accomplished through synthetic training and the maximum employment of training devices. The tactical situation of Phase I can be synthetically duplicated to produce the operational condition. Electronic computers can be used to solve a myriad of equations, to simulate speedily and accurately the problem that can and probably will involve continents, millions of people, and the application of numerous weapons. Speeds, relative movements, intercepts, weather conditions, and many other factors will be cranked into the problem to burden the electronic brain and test the human skills of the trainees.

Does history support the contention that training without weapons is possible? Very much so! Hitler did it, and successfully, too. The British also found that synthetic training paid off handsomely. Why, then, do we not exploit this specialized field of training to its maximum?

We are touching the outer fringes of this potential with the employment of tactics trainers that are in use in some of our staff colleges. To obtain a clearer picture of the employment of such devices and the utilization I have indicated for Phase II, see Figs. 9 and 10.

Before leaving the application of training devices to future weapons and tactics, I should like to mention briefly training as it pertains to space travel. Inasmuch as our jet fighters, bombers, and experimental rocket-powered airplanes are today traveling along the very borders of the upper atmosphere, their crews are approaching the environmental hazard that exists in the void of space. Therefore, space travel for the engineer is merely a projection of today's routine operations. Space travel planners are alert to the training problem involved. You may recall the series of articles in the February and March, 1953, issues of *Colliers*

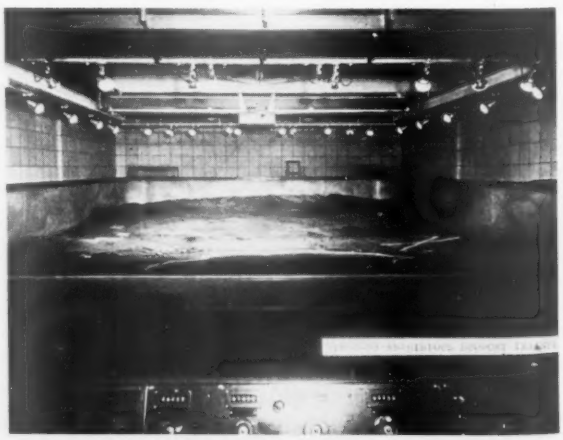


FIG. 9. Amphibious support tactics trainer.

in which it was stated that only 5 out of every 1,000 persons can meet the initial rigid educational, physical, and age requirements for *space training*. This is just enough for one rocket ship crew. Also portrayed in these articles was the synthetic training and training devices to be used in simulating the problems to be encountered in outer space. These planners are well aware that their tasks allow *no* margin for error, and, therefore, training and simulation of task offer the *only* means of guaranteeing adequate human performance.

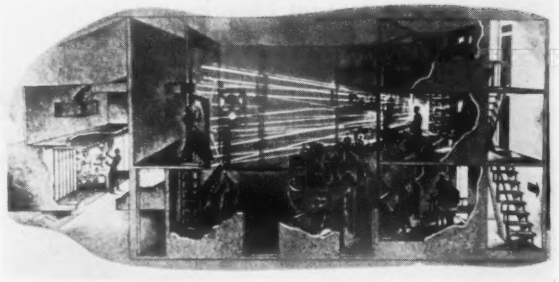


FIG. 10. Maneuvering tactics trainer.

(IV) THE PROPOSAL

Does all this have a bearing on you and me? Yes, I think it definitely has. It is becoming increasingly apparent, after Korea and Indo-China, that there will be no permanent peace in our times until the free nations *are capable* of quickly and effectively repulsing aggression wherever it occurs. The major portion of this task, of course, falls on the United States. When we ask whether this capability will be realized, present defense economies, cutbacks, and stretch-outs appear to postpone that day and make it more difficult to predict. Are there any means whereby this capability can be speeded *within* our present economic limitations? Yes, I believe that there are.

The *individual's* will to defend his country or to fight for what he feels is right is this country's greatest asset. But his will to fight and his effectiveness while fighting are to a large extent the result of the confidence he has gained in himself and his weapons during his training period. Nothing dispels mystery and fear as fast as knowledge and practice. And this is particularly true of the horrible game of war. As was pointed out to you earlier, prohibitive costs and hazards of peaceful employment may obviate the use of H-bombs, nerve gas, and germ warfare for operational offensive and defensive training of adequate numbers of military and civilian personnel. Yet, this training is essential to *individual* performance. Therefore, synthetic training and training devices may be the *only* way large numbers of people will ever be trained in the latest weapons.

The lessons learned from history, the present state and employment of the art, and the very nature of our latest weapons stress the importance of the proposal to exploit training devices to the maximum and to recommend their incorporation at the weapons planning stage. By maximum, I mean the application to new weapons of similar thought, similar development, and similar employment of training devices which are now being applied to current operational weapons. For this to become a reality, synthetic training and training devices must be introduced at the weapons planning stage. For it is here that personnel employment and training policies are established. This, in my opinion, should occur at the earliest possible moment.

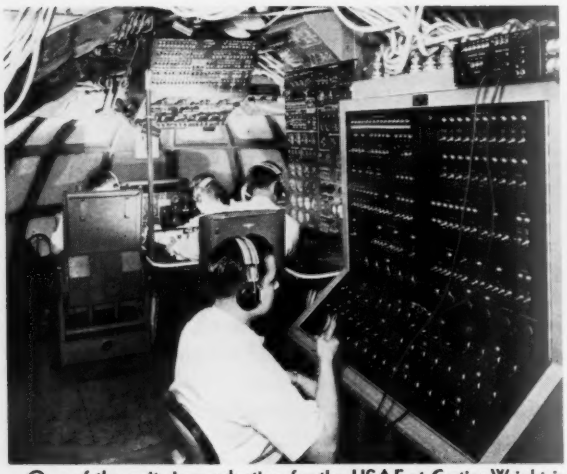
Last Call for *Roster* Listing

You are reminded that the *Roster* data card previously issued to you must be filed immediately if you wish to change your listing in the 1954–1955 edition.

Those members not returning the data cards will be listed by repeating the entry that appeared for them in last year's *Roster*. This is your last opportunity to be correctly listed in the 1954–1955 IAS *Roster of Members*.

Some Recent Developments

(*Continued from page 69*)



One of the units in production for the USAF at Curtiss-Wright is a Simulator for the Boeing C-97A. This photo looks forward into the cockpit and shows the pilot, copilot, and flight engineer at work. In the foreground is one of the instructors seated at the Trouble Console.

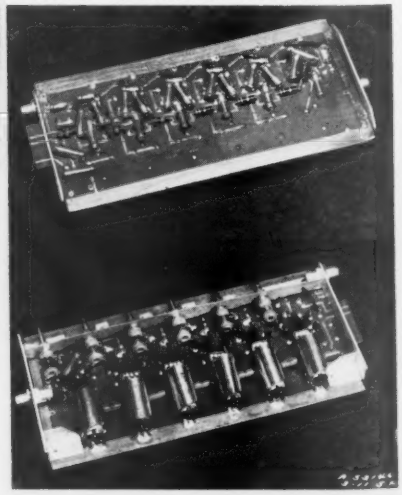
Overall interior view of Link Aviation's latest and largest jet flight simulator, the F-89D, showing flight simulator, *foreground*, and flight and radar instructor's area, *above*.

A recent development in the specialized test equipment field is this compact Survey Wavemeter designed by the Electronics Division of Thompson Products, Inc.

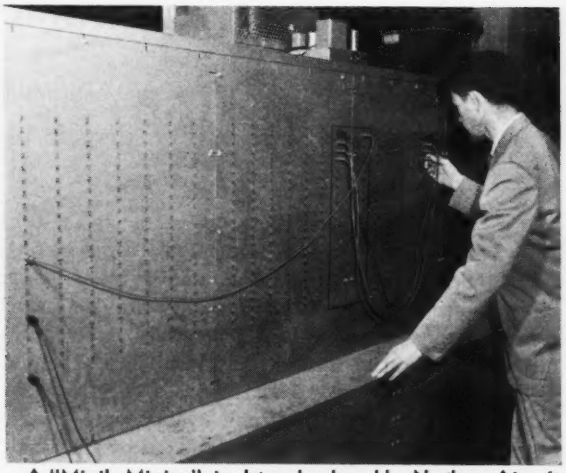
A small, easily handled air-borne recorder to log all important data on flights of missiles or airplanes for as long as 10 hours has been designed and produced by North American Aviation, Inc.

Summers Gyroscope Company produces this Model 29 Free Gyro, which operates on 28 volts d.c., has a single-axis potentiometer pickoff, and is suitable for application in the telemetering or control of aircraft, guided missiles, or water-borne vehicles.

Developed by the Electronics Department of The Glenn L. Martin Co., this compact, 7-in., high-gain radar receiver has etched wiring, which simplifies production and assures circuit uniformity.

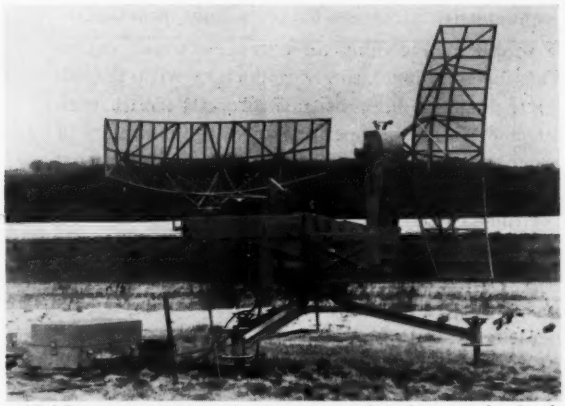


Guided-missile flight-test data radioed to earth as a bedlam of scrambled sound now can be automatically unscrambled and heard as separate scientific messages by this new electronic instrument recently unveiled by Lockheed Aircraft Corporation.



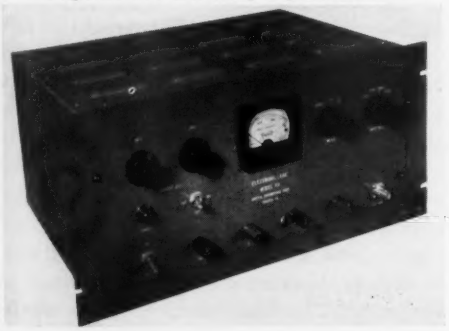
A "Missile Mission" simulator, developed by Northrop Aircraft, Inc., makes it possible to "launch" and "fly" a missile through any predesignated flight without the missile ever leaving the ground.

An electrical-optical "brain" developed by North American Aviation, Inc., gives instant data on how fast an airplane "hits the deck" or lands.

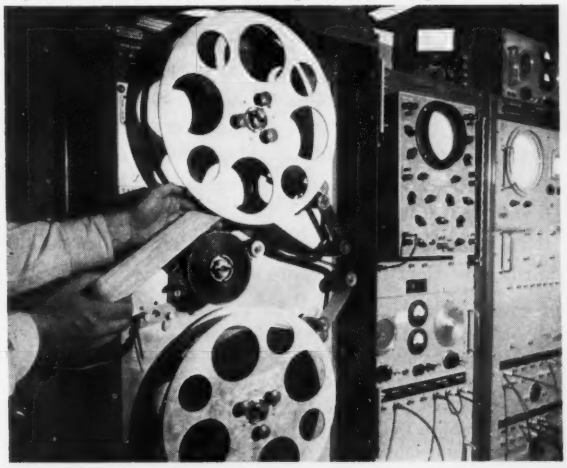


SPAR, an inexpensive precision approach radar recently developed by Laboratories for Electronics, Inc., now makes it possible for the smaller airports to operate under all kinds of weather conditions.

Bristol Engineering Corporation's Model 101 Electric Load is a device primarily intended for testing and calibrating regulated power supplies and is suitable for laboratory or production use.



Telemetered information of a pilotless aircraft flight is put into visible form at Boeing Airplane Company by this device, which by means of electric "needles" burns black-dot code into conductor-backed paper. Six hundred feet of the paper shown are needed to impart information received in a single minute of flight.



Liquid Cold-Plate Method for Cooling of Air-Borne Electronic Equipment*

MARSHALL P. SANDELIN†
The Glenn L. Martin Company

ONE OF THE MOST pressing problems facing the contemporary air-frame designer—heat—presents an even greater problem for the designer of air-borne electronic equipment. Packaging must provide means for alleviating the excess heat generated by the equipment or introduced into its environment. The development of a method that promises effective heat transfer from aircraft electronic components to the outside atmosphere has been undertaken by the Engineering Division of The Glenn L. Martin Company. This is the liquid cold-plate system—a technique long neglected because of its weight penalty but which now, with refinement, promises to be wholly practicable.

The problem of cooling air-borne electronic equipment has become increasingly important with the advent of high-speed, high-altitude aircraft. With each improvement in aircraft performance, the efficiency of the weapon and its basic ability to fulfill its mission become successively more dependent upon the reliability of the electronic gear.

Equipment reliability can be obtained only through the provision of a separate environment-free cooling system, designed to protect the electronic components whether the aircraft be air borne or on the ground. Weight and space considerations favor compact module packaging, which, together with miniaturization of elements, results in a marked increase in heat density in the immediate vicinity of the electronic equipment. This build-up of heat density defines a problem that will continue to grow more and more pressing.

The purpose of many of the development studies being conducted by various agencies analyzing this problem has not necessarily been to propose solutions but to supply the factual basis from which solutions might be evolved. It has been the purpose of the Martin program to combine the factual bases investigated by others,‡ together with the results of the company's own current development work, into a practical and integrated solution adaptable to aircraft presently under consideration and to the electronic equipment they must carry.

Before advocating any particular method for cooling air-borne electronic equipment, the following were given consideration: liquid immersion; spray cooling; evaporation, both direct and indirect, with expendable and nonexpendable coolants; and ram air with cold plate. Special study was given to the feasibility of systems utilizing the forward motion of the aircraft to provide cooling air. Here, however, one encounters the inevitable problem of an excessive rise in ram air temperature at high flight speeds. Pressure, density, and other considerations likewise tend to limit the utility of ram air to altitudes below 45,000 ft.

A cooling system that is independent of air-borne environment has therefore been found most eligible for all present, as well as future, high-performance aircraft. It was in view of this that the liquid cold-plate system was selected for development. For use in piloted aircraft, it appears that some type of environment-free liquid heat-transfer system will be necessary and that, on pilotless aircraft having a relatively short flight duration, an expendable-coolant evaporation system might well prove best. For an ultimate solution, nevertheless, a combination using some features of the other available methods need not be ruled out of consideration.

Dissipation of heat originating in air-borne electronic equipment is accomplished by the liquid cold-plate method in terms of two major design phases, as follows:

(1) Provision of a suitable structural configuration for the overall installation, combining support and space accommodation of the electronic equipment with the essential thermal contact with a heat-transfer surface, and for conducting or convecting the heat from individual components to the heat-transfer surface.

(2) Provision for conveying the heat load from the heat-transfer surface to a suitable heat exchanger and for ultimate dissipation of the excess heat overboard into the atmosphere surrounding the aircraft.

The method of cooling selected for this study is based on obtaining the greatest possible effectiveness of heat transfer from the components within the equipment to the point of eventual discharge. Conduction affords the best means of transferring heat from the equipment to the cold-plate heat sink. From that point, it is transferred by a medium of high specific heat, such as an appropriate liquid, to a heat exchanger. In the heat exchanger, this heat can be transferred across a compact area to some kind of an ultimate heat sink.

There are many possibilities in the development of an ultimate heat sink. The final selection of one would

* Appreciation is extended, for their assistance in the liquid cold-plate cooling system development, to Albin M. Nowitzky and Richard A. Bateholts, of the Aerodynamics Department, and to the following members of the Electronics Department: Earl Kirkley, Alfred E. Shanks, and Edwin R. Dunkelberger.

† Electronics Department, Engineering Division.

‡ See Bibliography.

depend upon the nature and purpose of the aircraft involved. One possibility is the transfer of the heat from the equipment to the skin of the aircraft. In some cases, the fuel used for propelling the aircraft might be a suitable liquid for effecting this transfer. In many types of aircraft, the cycle can be expanded to utilize a liquid-to-air heat exchanger in a cabin air discharge system, which might be supplemented by additional bleed air prior to the discharge overboard. Unlike ram air, cabin discharge air, together with the supplementary refrigerated bleed air, should be available in adequate quantity and pressure.

Figs. 1 and 1a illustrate a hypothetical installation of the proposed cooling system in the electronic equipment compartment of a modern airplane. It illustrates the utilization of cabin discharge air, with the possible addition of supplementary bleed air, passing through a compact efficient heat exchanger prior to being discharged overboard.

It should be understood that, under certain operating conditions, the heat exchanger can be cooled entirely by cabin discharge air. At high altitudes, the cabin discharge air is likely to be reduced in quantity. Therefore, supplementary bleed air from the expansion turbine should be added to the cabin discharge air to obtain a mixture that will cool the heat exchanger in an effective manner.

In the past, the principal objection to liquid cold-plate systems was weight. This drawback has been overcome by a unique method of cold-plate construction. It combines a rugged, lightweight structure carrying a minimum quantity of liquid. This liquid transfer medium would be some suitable fluid, such as a water-alcohol mixture or one of the ethylene glycol compounds.

The honeycomb employed in this construction is a Martin engineering development widely used in the aircraft industry wherever a rugged, lightweight structure is needed. It consists of an aluminum honeycomb core sandwiched between two lightweight sheets of aluminum—bonded, under pressure and heat, into an integrated structure. Bonding is accomplished with a phenolic-vinyl thermosetting resin type of adhesive, FM-47.

Each external layer of the cold-plate assembly, illustrated in Fig. 2, is an individually sealed subassembly consisting of two sheets of aluminum plus distribution headers. The outer surface is flat. The inner sheet is made in the form of a shallow dish. This construction permits the passage of a thin layer of liquid through the enclosed section—the liquid picking up the heat from the outer contact surface.

The honeycomb core, sandwiched between the two outer layers, provides sufficient strength and rigidity to support the equipment mounted against the structure. Inlet and outlet headers, one at each end of the layer, provide proper distribution of the liquid to both surfaces of the cold plate and equalize the velocities and pressure drops across its entire surface. The

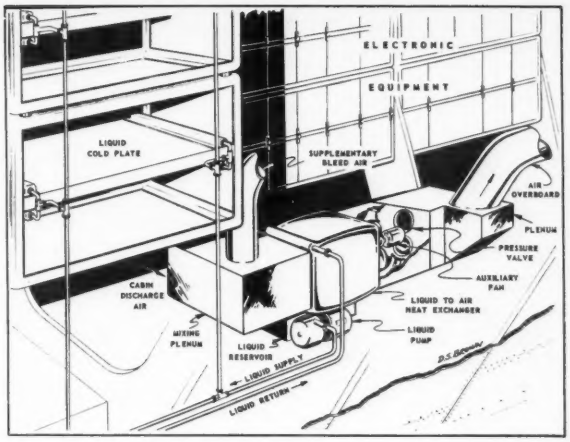


FIG. 1. Proposed liquid cold-plate system installation utilizing cabin discharge air for removal of heat generated by electronic equipment.

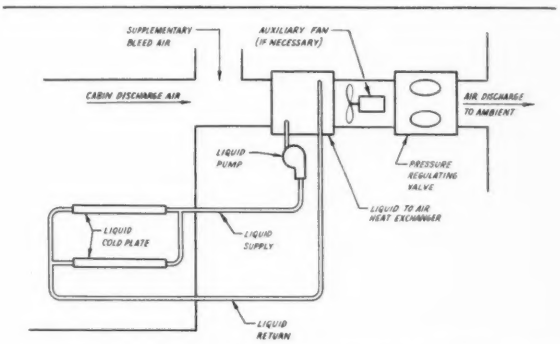


FIG. 1a. Schematic diagram of liquid cold-plate cooling system utilizing cabin discharge air.

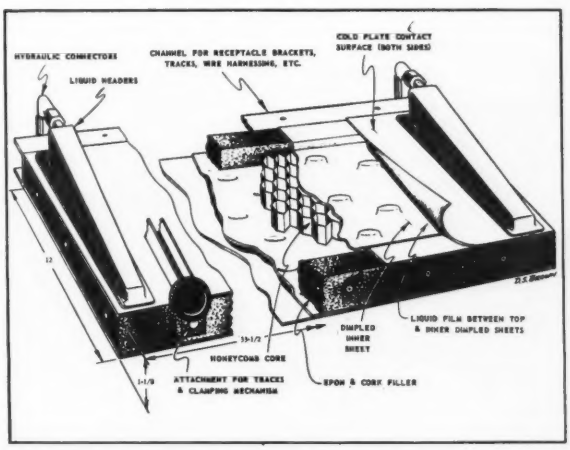

HYDRAULIC CONNECTORS
LIQUID HEADERS
CHANNEL FOR RECEPTACLE BRACKETS, TRACKS, WIRE HARNESSING, ETC.
COLD PLATE CONTACT SURFACE (BOTH SIDES)
LIQUID FILM BETWEEN TOP & INNER DIMPLED SHEETS
DIMPLED INNER SHEET
HONEYCOMB CORE
ATTACHMENT FOR TRACES & CLAMPING MECHANISM
EPON & CORK FILLER

FIG. 2. Liquid cold-plate construction details showing liquid passages, distribution headers, and honeycomb core.

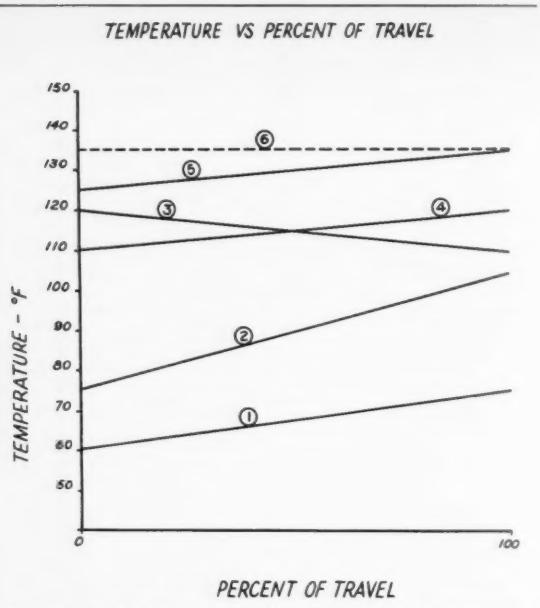


FIG. 3. Graphical representation of approximate temperature limits of electronic equipment and cyclic operation of cooling media, using liquid in the cold plates and cabin discharge air for transfer of heat to ultimate sink: (1) flow of air through cabin; (2) flow of cabin discharge air through heat exchanger; (3) flow of liquid through heat exchanger; (4) flow of liquid through cold plate; (5) temperature rise of cold plate; and (6) average ambient temperature of modules.

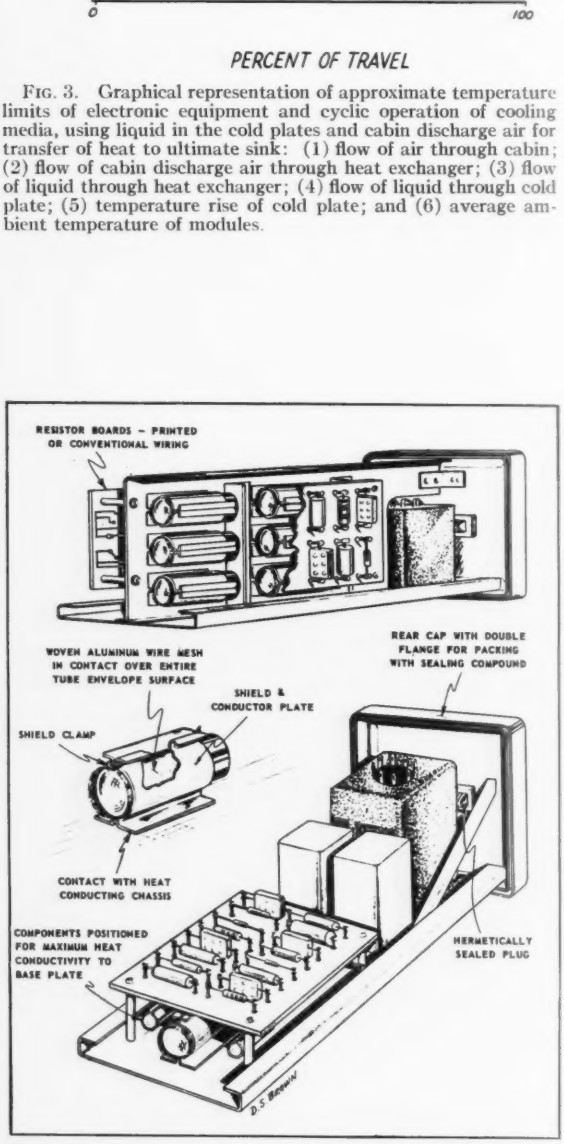

RESISTOR BOARDS – PRINTED OR CONVENTIONAL WIRING
WOVEN ALUMINUM WIRE MESH IN CONTACT OVER ENTIRE TUBE ENVELOPE SURFACE
SHIELD & CONDUCTOR PLATE
REAR CAP WITH DOUBLE FLANGE FOR PACKING WITH SEALING COMPOUND
SHIELD CLAMP
CONTACT WITH HEAT CONDUCTING CHASSIS
COMPONENTS POSITIONED FOR MAXIMUM HEAT CONDUCTIVITY TO BASE PLATE
HERMETICALLY SEALED PLUG
D.S. BROWN

FIG. 4. Illustration of component packaging of modular units.

edges of the assembly are easily sealed by use of aluminum channels or other means.

A simple clamping mechanism provides a guide track and assures a thermal bond between the cold plate and the electronic equipment surface. It also serves to apply pressure, making firm contact with the electrical connectors located in the rear of the equipment. All liquid connections and the electrical harnessing of the equipment are made at the rear of the module.

Assuming that a system could be designed to use cabin discharge air as the ultimate sink, its cyclic operation may be graphically represented, as in Fig. 3, to show the approximate working limits of such a system from a temperature standpoint.

Physical size and weight are important considerations in the design of a system utilizing cabin discharge air. A heat exchanger capable of dissipating 5 kw. of heat load has been estimated to displace 729 cu. in., with a weight of less than 20 lbs., when filled with its liquid medium. This is based on a cabin discharge airflow, entering the exchanger, of 45 lbs. per min., at 7 lbs. per sq.in. absolute. Individual cold-plate structures of the particular system, designed to handle a 1-kw. heat load with dimensions capable of dissipating a heat density of 2 watts per sq.in. of surface area, weigh about 8 lbs., including structure, headers, and liquid.

The liquid cold plate can absorb higher heat densities than 2 watts per sq.in., provided the electronic equipment can be packaged for this heat concentration and that suitable ultimate heat sink provisions are incorporated. The weight of the enclosed liquid and associated tubing is governed by the requirements of the individual installation; however, estimates show it to be approximately 0.174 lb. per linear ft. With proper construction, the pressure drop across the entire system will be relatively small, requiring only a compact, lightweight pump.

A unit console or rack may be designed to incorporate a cold-plate assembly with the individual chassis, in modular form, mounted against either the top or bottom surfaces of the cold plate.

This console incorporates provisions for accommodating the plug-in features built into the rear of the modules. Both the front and rear surfaces of the rack provide means of securing the modular units and are built with the popular quick disconnect feature and interlocks, in accordance with good military design practice.

Cell, or modular construction, represents packaging in its most objective form. Notable contributions to the philosophy underlying this type of construction have been made by Raytheon Manufacturing Company and International Business Machines Corporation during the development of ram air cold-plate systems of their own design. Equipment configuration can be made compatible with specification MIL-C-7452 (USAF), which establishes the limiting design dimensions for pressurized and nonpressurized electronic equipment cases.

Designed as a plug-in module, the individual unit is constructed with carefully considered form factors, which develop optimum groups of physical standards and provide for the greatest degree of versatility in design and application. (See Figs. 4 and 5.)

The individual modules are mounted flush on the cold plate, thus affording the maximum possible transfer of heat from the components to the liquid medium, by conduction. The electrical and electronic parts within the modules are arranged to assure the greatest amount of heat transfer from these components to the cold plate. The construction used in the modules takes into account all of the applicable practical techniques available to advanced electronic design and circuitry, including printed wiring.

Conduction of heat from the individual components is used whenever possible, though certain types of components demand the limited use of other heat-transfer techniques such as forced convection or liquid immersion. Designs that place high-temperature components directly against the module base, with resulting good thermal conductivity, produce the best results. The available contact surface, however, is somewhat limited.

Thin metallic sections used as conductor plates, when incorporated in the module's design, perpendicularly mounted to the cold-plate surface, perform two functions. They serve as a supporting element in densely packaged equipments and constitute an extension of the cold-plate surface. This permits considerable miniaturization, with resultant heat concentration, since greater heat density can be accounted for and the excess transferred to the available cold-plate surface with a relatively small increase in the equipment ambient temperature.

Ultimate design objectives, including a packaging philosophy, will make mandatory the conception of an overall hermetically sealed construction, possibly including pressurizing with an inert gas such as helium. This will assure an environment in which altitude, corona, humidity damage, and similar problems will be obviated without compromising the system's high heat-transfer characteristics. Moreover, the development of an inexpensive and expendable modular unit is universally recognized as highly desirable.

Fig. 6 shows the aircraft installation of a group of consoles assembled to form an integrated group. The standardization of modular size will be instrumental in establishing uniform cold-plate and unit console sizes. The shape and other form factors involved in their design will permit the greatest degree of versatility, envisioning installation in any type of air frame. Racks of modular units can be grouped to give a variety of combinations, flexible enough to provide the best possible installation facilities in any aircraft.

Antishock provisions and vibration isolators can be provided easily throughout the unit consoles, if found to be necessary. In fact, the entire assembly, or any part within it, can be isolated from the air frame.

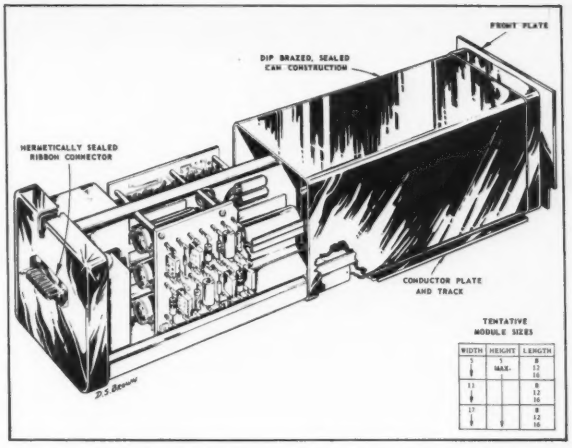


FIG. 5. Typical modular assembly with tentative module sizes.

While it is not offered as a panacea, the liquid cold-plate method certainly possesses many inherent points of advantage that must not be overlooked when selecting a cooling system for air-borne electronic equipment:

(1) Effective heat transfer is assured by the addition of a small pump, which provides a high degree of system flexibility in controlling the coolant temperature differences. Control of the pressure and velocity of the cooling medium can readily be achieved, as dictated by the equipment locations, heat loads, and exchanger types and sizing.

(*Continued on page 93*)

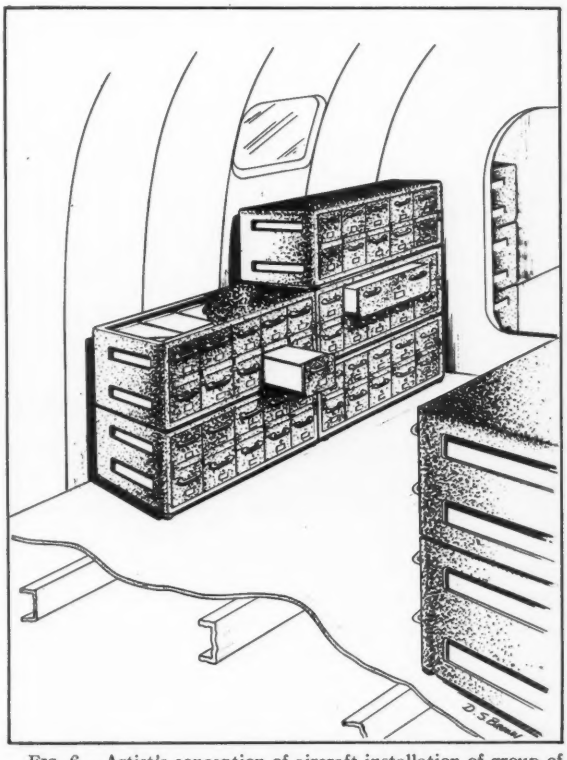


FIG. 6. Artist's conception of aircraft installation of group of modular unit consoles. Size, orientation, and assembly of units may be varied to suit installation.

The Use of an Operational Flight Trainer as a Research Tool for Aircraft Instrumentation and Cockpit Rearrangement*

JOSEPH N. PECORARO†
Special Devices Center, ONR

Introduction

Working in the training and educational field, we at the Special Devices Center have always been interested in the human problems of safety and efficiency associated with aircraft flight. In June, 1950, the Center established an Aircraft Simulation Laboratory for the purpose of developing a new concept, that of using training devices as research tools in programs aimed at improving the cockpit arrangements and instrumentation displays of Military aircraft. As you are aware, cockpit instrumentation has failed to keep pace with the rapid development of the aircraft and has, in fact, just "growed," like Topsy, with modifications being made to old instruments to suit new requirements or a new face being added without consideration of the psychological effect on pilot safety and efficiency or of integration with the existing instruments. Psychologists and engineers, working in the new field called Human Engineering, collaborated on these problems using simulated rather than actual flight conditions.

During that same year, 1950, the Office of Naval Research and the Bureau of Aeronautics of the United States Navy accepted the concept of engineer and psychologist team and requested the Center to undertake several tasks using simulation techniques and Human Engineering studies for evaluation of new instruments. This eliminates, in some cases, the more costly methods of building working prototypes and conducting full-scale flight tests. In addition to the modification of simulator for research work, the Center, during the past several years, has developed other equipment for use in simulation, as well as new scoring techniques for evaluation purposes.

The overall instrumentation of helicopters and jet aircraft has been our primary interest in the Air Applications Branch (Figs. 1 and 2). One example of our work in this field is the evaluation of a V-G display under *actual* flight conditions. Besides being costly, it is dangerous to flight personnel and flight equipment. But with the new techniques, actual flight conditions are simulated, and comprehensive problems that will be shown to you later can be conducted and scored quantitatively, while the aircraft as well as human variables are controlled. In all simulation experiments, it is understood that some compromises must be made. In this case, that of the V-G instrument, physiological cues, provided by inertia forces, are missing. However, a human centrifuge can supply the additional study if desired or necessary. A valid comparison between displays can be made without these cues since the environment is standardized in this respect for all the tests.

My purpose is to report to you the progress that we have made, methods used, and the conclusions that we have drawn. Because security and other factors limit this discussion, the results of our instrument evaluations will be narrowed to one or two specific examples.

Methods

A task from its inception is usually handled as follows:

(1) A psychological and engineering field survey is made leading to a job analysis.

(2) Engineer-Psychologist cooperation determines suitable new or modified configurations satisfying both the job analysis and engineering considerations.

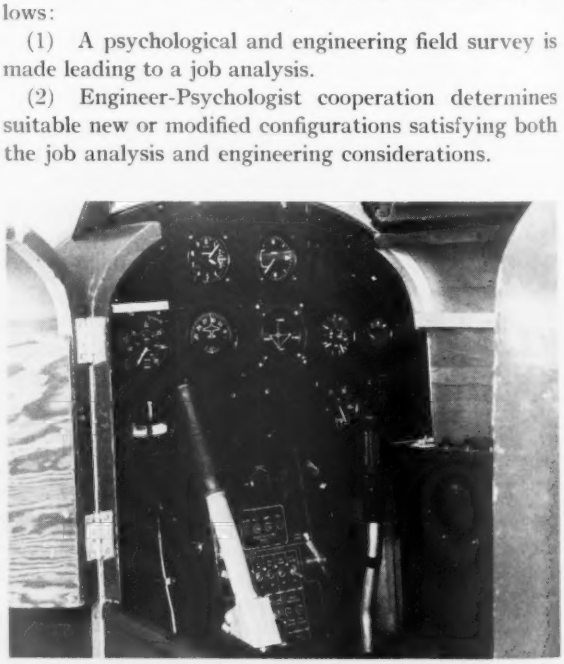


Fig. 1. Helicopter simulator instrument panel (modified 1AA-1 link as a research tool).

Presented at the Flight Safety Session, Twenty-Second Annual Meeting, IAS, New York, January 25–29, 1954.

* Stanley Aviation under contract to the SpecDevCen provided engineering and psychological assistance for the pioneering of this new concept.

The opinions expressed in this article are the author's and not those of the Department of the Navy.

† Head, Air Application Branch, Aviation Division.

(3) Equipment is constructed to *simulate* the various practical configurations resulting from the cooperative efforts of engineers and psychologists in the design phase above.

(4) These several configurations are evaluated in the simulation laboratory, using, as far as possible, actual measurements of operator performance.

Principles Governing Instrument Design and Cockpit Layout (Design Phase 2 Above)

Before proceeding further on the evaluation of a specific display, it is desirable to indicate in a general manner the basis of selection of certain physical features of the displays. These can be grouped in three categories, as follows.

(1) *Principles Relating to Design Features of Individual Instruments.*—Such as legibility, dial markings, pointers, zero position, counters direction, in relation to controls.

(2) *Principles Relating to Location and Arrangement of Multiple Indicators.*—The principles in this category seem to represent the best current "opinion"—i.e., functional grouping, pattern display, basis of location, in-line indicators, relation to controls, angle of displays, etc.

(3) *Principles Relating to the Arrangement of Control Devices.*—As an example of these would be: efficient working area, efficient use of both hands, organization of procedural steps, controls of similar functions, frequency of use, etc.

A guide used to arrive at a proper application of these principles is the report[1] of the Armed Forces NRC Vision Committee, summarizing general rules to be followed by instrument designers. Other sources are the Special Devices Center Handbook of Human Engineering Data.[2]

Techniques

As noted above, following an analysis of the information required by pilots, a number of instrument displays may be proposed with the objective of presenting the required information more efficiently than instruments now in use. It is at this time that the engineer initiates construction of equipment for simulation and, at the same time, the psychologist prepares an evaluation program whereby the merits of the several proposed displays can be determined by means of a series of experiments that compare them with each other and with standard displays. In general, the experiments are designed to answer "which display enables operators to maintain specified flight conditions most accurately and with minimum effort under normal or under adverse conditions?" The proposed experimental designs make provisions for determining specifically: (1) with which display proficiency is more rapidly acquired and (2) with which display control is more efficient when the operator has attained a given level of proficiency (or has had a given amount of experience in this situation).

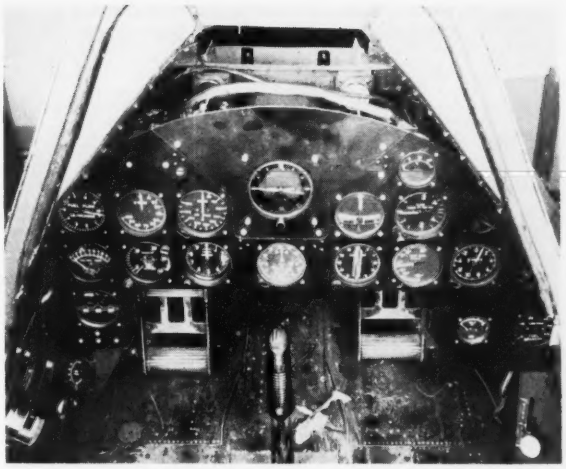


Fig. 2. Jet aircraft simulator instrument panel (modified AD-1 operational flight trainer).

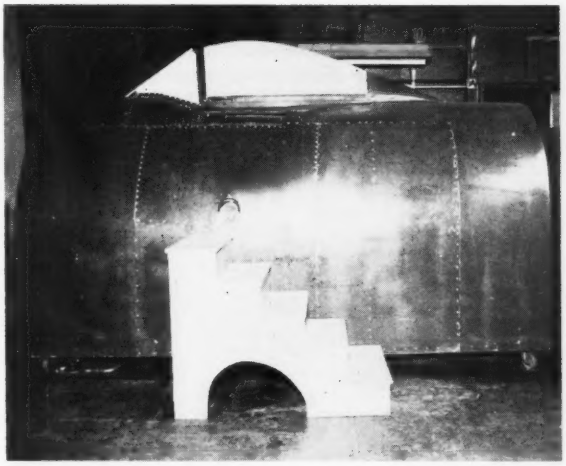


Fig. 3. Jet aircraft cockpit simulator.

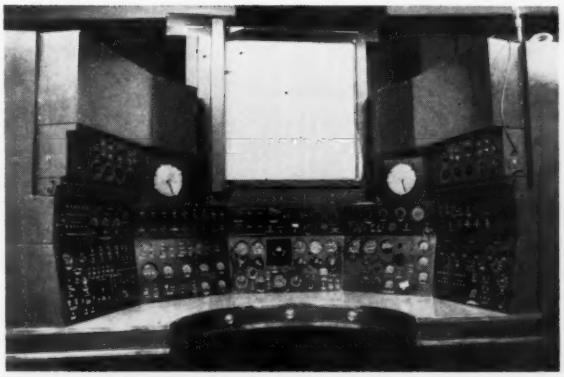


Fig. 4. Simulator instructor's station with duplicate set of cockpit instruments.

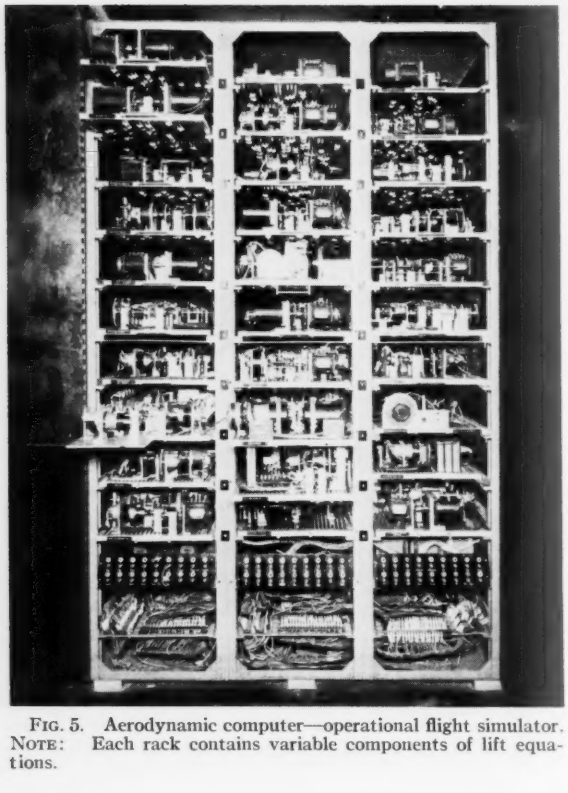


FIG. 5. Aerodynamic computer—operational flight simulator. NOTE: Each rack contains variable components of lift equations.

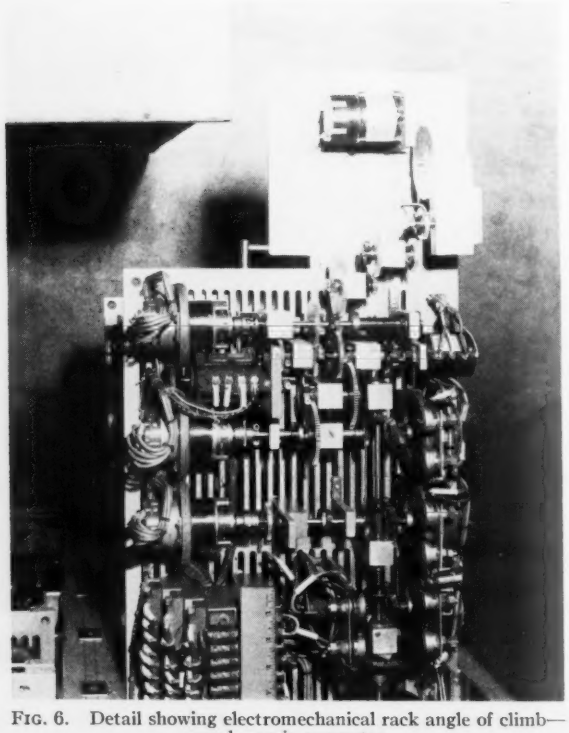


FIG. 6. Detail showing electromechanical rack angle of climb—aerodynamic computer.

THE OPERATIONAL FLIGHT TRAINER

An Operational Flight Trainer (*O.F.T.*) was used as the test vehicle for the evaluation program (Fig. 3). The trainer was built originally to simulate the AD-1 airplane, but later it was modified to reproduce the flight characteristics of the F9F-2 airplane. This further exemplifies the versatility of such a device as a research tool. In the trainer, for those of you not familiar with the O.F.T., the pilot can duplicate procedures encountered in flying jet aircraft. The instructor, or in our case the experimenter, can monitor and check his performance by means of a duplicate set of flight instruments and discuss the maneuver with the pilot (Fig. 4). The instructor also can set and vary flight conditions.

The complete O.F.T. consists of a cockpit, computer racks, experimenter's table, containing monitor instruments, and associated electronic and mechanical equipment. While simulation of the cockpit is realistic, no movement of it or the pilot is used to simulate the sensation of acceleration forces during flight maneuvers. The illusion of flying is created through the sensation of simulated aerodynamic forces on the stick, engine noise, and instrument indicators.

The computer is of the electrical-mechanical type and calculates interactions among controls, aerodynamic forces, power plant, and instruments (Figs. 5, 6, and 7). The results are presented to the pilot on his instruments; thus, the computer *supplies intelligence* to the displays being evaluated and to the scoring equipment.

SUBJECTS

Normally subjects who are equally unfamiliar with all the displays that are to be evaluated are the logical choice for the initial phases of the evaluation program. In fact, if any of the proposed displays are to be compared with the standard displays with the objective of finding which of them enables an operator to acquire proficiency more rapidly, naïve subjects must be used, since skilled pilots are already familiar with the standard displays. It is impossible to say generally how long a novice would have to be exposed to a given combination of instruments before his performance curve would become essentially level. When the experienced pilots are brought into the picture, it is important that the equipment and environment be realistic and that the new displays perform satisfactorily. At this time also, the purpose of the experiment and experimental design is carefully worked over to suit situations realistic to the pilot. The pilots in this phase of experiments must represent the current operational group. In our case the helicopter and jet instrument displays were evaluated using pilots from the Naval Air Force, Atlantic Fleet (HU-2, VX-3, VC-4, etc.).

Let us see how the results of the evaluation are influenced by the subjects. The following factors are pertinent:

(1) Experienced pilots provide information as to the degree to which new instrument designs will permit pilots to perform more effectively. Incidentally, if the new display control is the reverse of the one previously learned or so-called standard, the results in the early phases of evaluation on these experienced subjects may be misleading. For instance, the standard directional indicator compass card moves from right to left when the aircraft banks to the right. An indicator card that moves in the same direction as the bank caused confusion to experienced pilots until the old habit was overcome, whereas, to the naïve subject, it was the natural direction.

(2) With respect to naïve subjects, data may be obtained as to degree with which training could be reduced because of better instrumentation.

Fig. 8 indicates schematically the performance curve obtained during evaluation with both subjects—naïve and operational pilots for each set of curves. The curves are derived from actual data but are presented here qualitatively to show the general trend.

On the upper curves, it is significant to note the difference in performance in the initial stages of testing naïve subjects. The training potential possible is suggested using this new instrument. It is assumed that, if training is continued, these curves should overlap the lower curves for the operational pilots.

On the lower curves, the first stage of the experiment indicates the time required for pilots to master the simulator characteristics. After the performance has stabilized, the differences between instruments (d) if statistically significant is the basis on which recommendation will be made.

The minimum number of subjects required for determining statistically significant differences depends, to some extent, on the nature of the evaluation—i.e., number of instruments involved, complexity of task, etc. In this program, because of engineering economics, as few as six subjects, tested under both instruments, provided significant differences. As a result of these findings, it can be shown that it is possible to use a relatively small number of subjects and obtain usable data, provided the subjects are given intensive testing, as well as individual detail interviewing.

Design of Realistic Evaluation Experiments

The experimental procedure for evaluation of instruments may be any flight problem such as climb, turn, and let-down or some pursuit problem, depending, of course, on the display being evaluated. For this paper I have selected the evaluation of an attitude instrument. Fig. 9 is a typical flight plan as given to the pilot to perform. The pattern shows a climb, a turn pattern, a let-down, and flight through to touch-down. (The psychologist has a similar flight plan.)

The pilot's ability to stay on course as shown and not exceed the standard limits is measured by pen recordings and by time-error integral scoring apparatus. Duplication of data in the form of pen recordings and

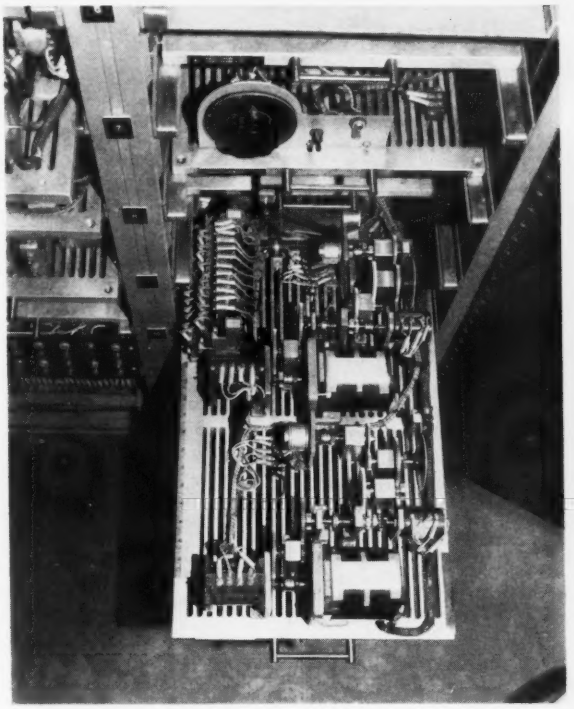


Fig. 7. Detail showing electromechanical rack ball and turn rate system—aerodynamic computer.

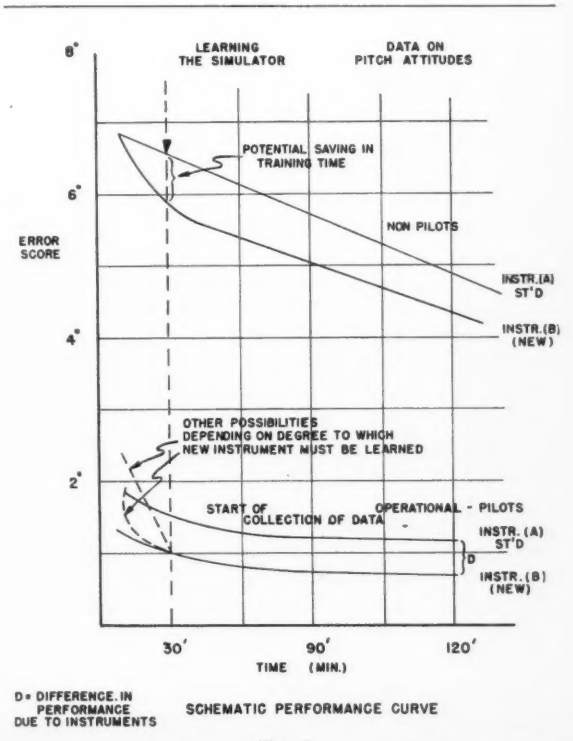
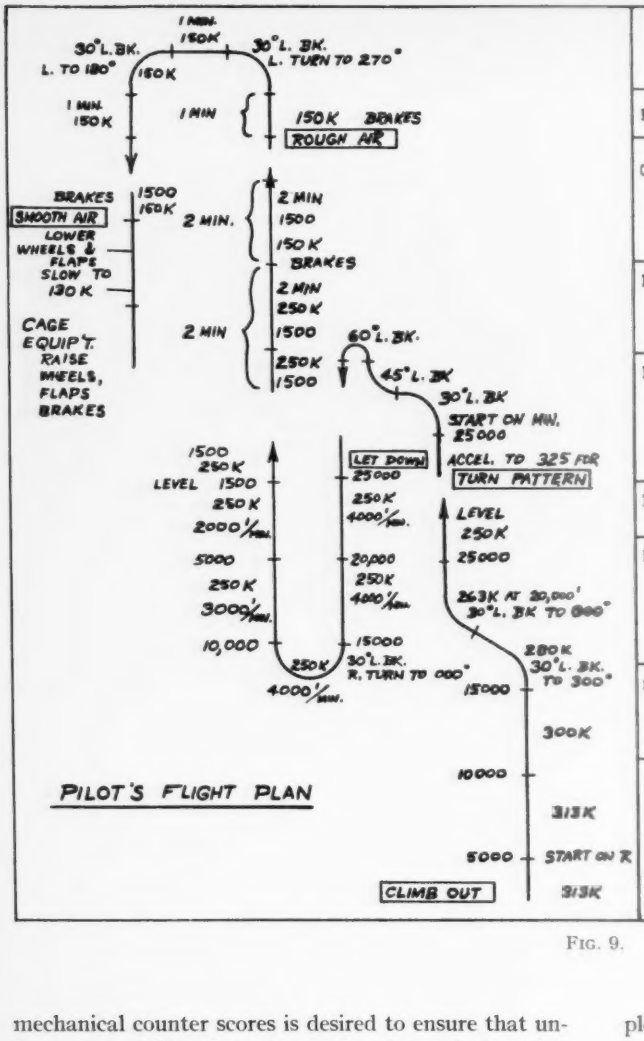


Fig. 8.



PSYCHOLOGIST'S FLIGHT PLAN

FLIGHT PATH	TIME	ALT.	IAS	R/C	BANK	HEAD.	RPM
CLIMB		5,000	313	(4500)	0	0	100%
		10,000	300	(3750)	0	0	100%
L. Turn		15,000	280	(3000)	30	300	100%
R. Turn		20,000	263	(2500)	30	0	100%
		25,000	250	(1750)	0	0	100%
LEVEL		25,000	325	0	0	0	100%
L. Turn		25,000	325	0	30	270	100%
R. Turn		25,000	325	0	45	0	100%
L. Turn		25,000	325	0	60	180	100%
LET-DOWN		25,000	250	4000	0	180	78%
		20,000	250	4000	0	180	
R. Turn		15,000	250	4000	30	0	
		10,000	250	3000	0	0	
		5,000	250	2000	0	0	
		1,500	250	0	0	0	
LEVEL	2	1,500	250	0	0	0	
Brakes	2	1,500	150	0	0	0	
ROUGH AIR		1,500	150	0	0	0	
Straight		1,500	150	0	0	0	
L. Turn		1,500	150	0	30	270	
Straight		1,500	150	0	0	270	
L. Turn		1,500	150	0	30	180	
Straight		1,500	150	0	0	180	
SMOOTH AIR		1,500	150	0	0	180	
Brakes, Wheels, & Flaps		1,500	125	0	0	180	

FIG. 9.

mechanical counter scores is desired to ensure that unforeseen variables that arise during the analysis period will be detected. The counter method is easier to analyze and may be the sole source of data for analysis if no unique characteristics are evident from the pen data. One other scoring device used to fill in on recorded data is photographic scanning of the duplicate panel monitored by the experimenter. You will note from Fig. 9, the sheet given to the pilot, that he is instructed as to the power setting and altitude for starting each test run. Since pilot technique is not being tested, the test will be simplified by maintaining this power setting throughout each run. This program involved the evaluation of several new combined attitude and directional indicators.

It can be seen that answers are available for every instrument and manipulation involved in each and every flight phase and maneuver. In this way, the significance and relative importance of each instrument and control can be assessed without danger of assigning a low priority to some instrument that is rarely consulted in flight as a whole but which is vitally important to some one phase of flight. One must remember that we are dealing with a complicated procedure in a complex machine and not with a factory assembly problem involving a bolt, nut, and washer.

PROBLEM

Let us, for purpose of further discussion, explain the simple problem of attitude in straight flight, since this is one of the more pertinent cues evaluated in instrumentation integration.

The normal flight requirement is that the pilot keep his aircraft straight and level when visual reference is impossible. The horizon is simulated with a gyro horizon.

Most attitude displays are of the symbolic type, but their presentation varies considerably. In general, these displays consist of a line representing the horizon and another bar or line to represent the plane's wings or lateral axis. These displays are arranged so that either the horizon bar or the wing bar remains fixed while the other moves to show the relation between the wing and the horizon. The displays where the horizon moves and the wing axis remains fixed to the aircraft frame are called "inside-out" displays. These have been found to be inferior to the "outside-in" displays in evaluation experiments conducted by the Air Force.

Both the standard gyro horizon (Fig. 10) and the directional horizon (Fig. 12) are "inside-out" displays. The pictorial horizon indicator (Fig. 11), consisting of a plane model mounted within a hemisphere, is an example of an "outside-in" display. Another display, the composite flight indicator (Fig. 12) works on a different display principle. This indicator shows the direction to which the control stick must be pushed to restore level flight attitude.

Following a suggestion set forth in the job analysis, a heading indication was added to the horizon indicator to produce a directional horizon indicator. This is shown in Fig. 12.

The various types of attitude indicators that seemed promising include the present indicator, two three-dimensional indicators, and the composite flight indicator.

The standard gyro horizon (Fig. 10) is included here for comparative evaluation purposes only. That is, its effectiveness and limitations as a blind-flying instrument can be determined by comparing it with the other instruments suggested. In this way, it will act as a "standard" for all the experiments.

Fig. 11, a three-dimensional display, is of the pictorial type. The representation of earth and sky is stationary and painted on a concave hemisphere, while the model airplane is free to move in pitch and bank. The horizontal reference line, which is attached to the instrument case, lies just behind the cover glass and is an extension of the painted horizon. The model airplane is pivoted at its wing tips, in a roll gimbal. The airplane has full freedom in pitch and roll. The instrument does not indicate changes in heading; therefore, a separate directional gyro must be used. The underside of the model airplane is striped in order to contrast with the solid-color top.

In the case of the directional horizon indicator (Fig. 12), the pilot imagines his airplane (the fixed lubber line) to be stationary, and the sky and horizon line could be made to indicate ground course if the appropriate wind information were fed in. A three-dimensional instrument, it is of the pictorial type. It has a horizontal reference line, rigidly attached (by means of the case) to the airplane structure. Behind this reference line, which represents the airplane, is a sphere mounted in a three degree of freedom gimbal and therefore free to move in pitch, bank, and yaw. This sphere, which is bisected by a line representing the horizon, synthesizes the pilot's view from the cockpit and is painted to represent earth and sky. The horizon line mounts a fixed reference index that indicates airplane heading on a numerical scale on the equator of the moving sphere. The display represents the view that a pilot would see in looking through a porthole directed forward.

The moving element of the composite flight indicator (Fig. 13) is a point of light or "pip" on a cathode-ray tube screen. This pip symbolizes the top of the control stick and, by its position, indicates to the pilot what corrective action he must take in order to move the pip

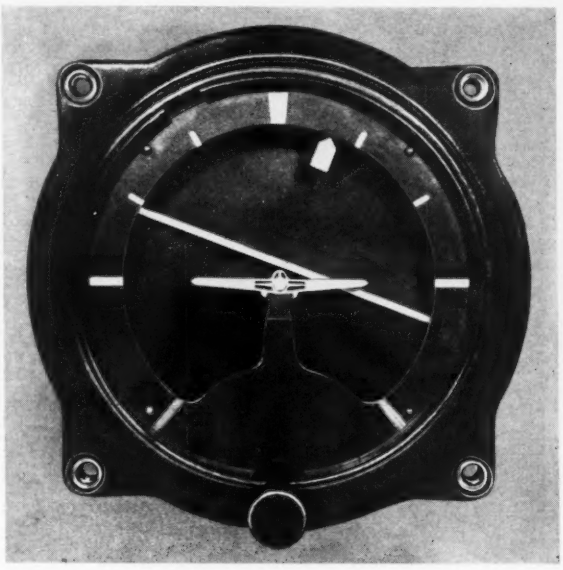


FIG. 10. Standard gyro horizon.

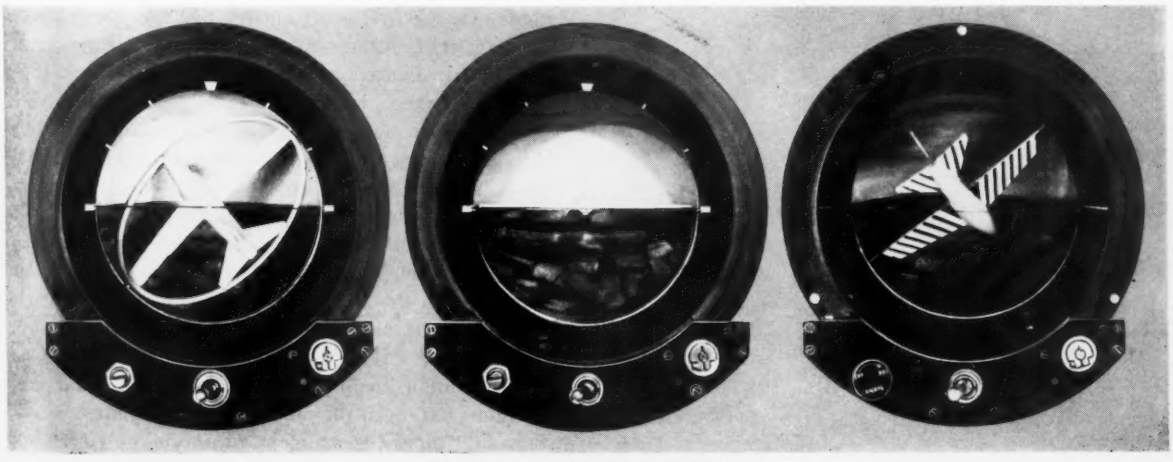


FIG. 11. Pictorial horizon indicator.

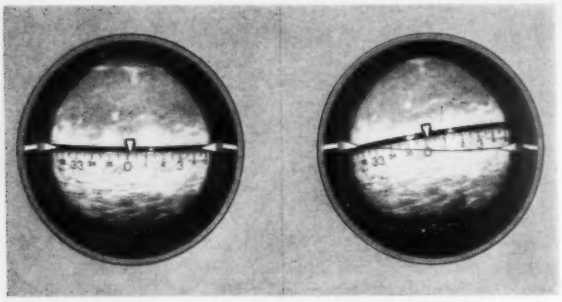


FIG. 12. Directional horizon indicator.

back to the desired center spot. A bank to the right moves the pip to the right; a dive moves the pip up. Under normal conditions, straight and level flight is achieved when the pip is centered on the cross hairs. Heading is displayed by a rotating compass rose.

CONCLUSIONS

Our experience to date on instrumentation simulation and evaluation, as noted previously, terminates at the recommendation phase with the reporting of the best practical displays or arrangements with measured evidence of improved operator performance. There normally should be two steps to evaluating completely new displays.

The objective evaluation test that has been outlined is a comparison of present with new or modified instrument displays with realistic simulation and controlled experiments.

The second is the subjective test by experienced Naval fliers. If practical, the same objective techniques should be used as in the simulation experiments.

There are disadvantages, as well as advantages, to both methods.

FIG. 13. Composite flight indicator.

The questions that may be raised in favor of subjective appraisal by experienced Naval fliers versus simulation techniques are:

(1) Are the results from the simplified test situation valid with respect to the operational situation?

(2) Are the so-called important parameters still present in the simple test situation?

Let us then summarize the conclusion that we have drawn from this program of objective (psychological) testing to date:

(1) *Economy.*—Simplification of new instrument displays for simulators was reflected in cost per instrument. Simulation and evaluation averaged $10,000 to $12,000 per instrument reported. This figure does not include the cost of pilots' time and expenses as subjects in the evaluation phase or the simulation cost, heat, power, etc. However, this cost figure includes the cost of the many other displays that came up during the study but which fell by the wayside during the first phase or, in one or two cases, during the simulation phase when, for either engineering or operational reasons, further expenditure of time on the suggested display was discontinued.

(2) A new source of design information is available for engineers or instrument designers for getting "empirical data."

(3) *Training Application.*—Simplified simulators were desirable for "naïve" or unprejudiced subjects, particularly for data on training time savings on instrumentation based on new instrument displays.

(4) A means for improvement of operating procedures by simulation of equipment systems.

(5) Subjective appraisal by experienced naval pilots under actual flight conditions is simple although the cost is greater.

(6) Subjective appraisal, although pilot opinion on the instruments' various features is still a decisive requirement in the military services. The ultimate would be objective scoring in actual flight. This phase of evaluation belongs to the material development agency, in our case, the Bureau of Aeronautics.

To date, final recommendations for new and modified instruments on the helicopter task have been distributed. On the jet instruments tasks, approximately 90 per cent of all the displays designed and constructed have been evaluated, and final recommendation on these should be forthcoming in reports by April, 1954.

I can report, however, that engineers, being practical individuals, do not always wait for validation data. On both tasks the job analysis reported displays features that were sufficiently specific for engineers to proceed concurrently with the simulation on the instrument development. This of course will reduce the time between the final recommendation report and the date when the instrument will be in operational use. Furthermore, it is safe to assume that the material development will consume sufficient time so that final recommendation in the objective evaluation can be incorporated in the instrument prototype and certainly by the time production of the instrument is frozen.

REFERENCES

[1] *Standards to Be Employed in Research on Visual Display*, National Research Council Vision Committee, March 1, 1950.

[2] *Handbook of Human Engineering Data for Design Engineers*, Tech. Report No. SDC-199-1-1, Office of Naval Research, Special Devices Center, Port Washington, Long Island, N.Y.

[3] Grether, W. F., *Discussion of Pictorial vs. Symbolic Aircraft Instrument Displays*, USAF, AMC Engineer. Div., Aero-Med. Lab., Memorandum Report TSEAA-694-8B, August 4, 1947.

Liquid Cold-Plate Method for Cooling of Air-Borne Electronic Equipment

(*Continued from page 85*)

(2) A set of liquid cold plates can be designed to serve the dual purpose of providing the required heat-transfer surfaces, as well as convenient storage shelves for the plug-in modular packaged equipment.

(3) For comparable heat loads, the quantity of air required for secondary cooling in a heat exchanger is less than that required for direct air cooling in conventionally packaged equipment. This is due to the more effective concentration of a large surface area in a small space and the increase of the overall coefficient of heat transfer. The weight and space savings resulting from the elimination of large diameter ducting to arbitrary locations in the aircraft can well be significant.

(4) Water or water-antifreeze mixtures recommended for use as the primary coolant possess high specific heats, which is conducive to efficient heat transfer. Further considerations are high thermal conductivity, plus low viscosity and low freezing temperature.

(5) A marked decrease in equipment volume, as well as a significant weight-saving, can be achieved by the liquid cold-plate system, since it permits of a high degree of miniaturization with the resulting increase in heat density.

(6) The amount of liquid required as primary coolant is small. Hence, the total weight of a liquid cold-plate system would probably not exceed that of the storage facilities ordinarily required to accommodate the electronic equipment, plus the weight of an alternative cooling system.

(7) The liquid cold-plate system presents no special logistic problem. The primary coolants recommended are fairly common, if not universally stocked. Moreover, in the event of an emergency, water is a convenient and desirable alternative.

(8) Since most present-day aircraft are marginal with respect to high-altitude and flight speed combinations, the liquid cold-plate method possesses an attractive growth potential beyond its adaptability to current designs. For increased range aircraft, such as those incorporating nuclear power plants, an environment-free system using a nonexpendable primary coolant might well prove highly desirable.

In conclusion, experience has indicated the critical need for an efficient cooling system for air-borne electronic equipment. The liquid cold-plate concept is based on sound principles of thermal transfer, so that reliance can be placed upon its ability to perform its mission in an adequate fashion, now that the problem of excess weight has been overcome.

BIBLIOGRAPHY

Robinson, Walter, *Systematic Cooling of Air-Borne Electronic Equipment*, Aeronautical Engineering Review, Vol. 12, No. 5, p. 81, May, 1953.

Robinson, Walter, and Zimmerman, R. H., *Methods for the Ultimate Dissipation of Heat Originating with Airborne Electronic Equipment*, Air Force Technical Report No. 6493, Wright Air Development Center, The Ohio State University Research Foundation, April, 1951.

Cooling of Airborne Electronic Equipment, The Second Conference at The Ohio State University, Vol. 1, 1953.

Members Please Note:

Have you returned your *Roster* Card?

(See page 79 of this issue.)

Operational Telemetering— An Aid to Air Navigation

M. V. KIEBERT, JR.*
P. R. Mallory & Company, Inc.

SUMMARY

The use of telemetering systems, techniques, and equipment is considered as an aid and safety factor for air navigation; as a potentially useful and essential system element in future air traffic control; and as an air safety element equally valuable en route and during take-off and approach.

Projected systems for use in each of these applications are described.

A telemetering system combined with a magnetic recording system located at each en route reporting station could provide an automatic and accurate cross reference against the filed flight plan. Based upon this automatic cross-referenced information, the pilot would be supplied with important en route factors that would provide material assistance in planning or carrying out the next leg of the flight plan.

For air traffic control, telemetered information from the approaching aircraft would be combined with G.C.A. information and surface wind data to provide accurate and optimum approach information.

Ultimate systems will close the servo loop and permit accurate automatic approaches under any and all ceiling and visibility conditions—factors of increasing importance with turbo-jet and high-speed transport equipment.

Equipment and frequency allocation problems are considered and do not appear to present an undue problem.

PRESENTATION

RADIO TELEMETRY has grown from the gadget stage of the postwar years and is now accepted as a dependable and invaluable research, evaluation, and test technique in piloted research aircraft and guided missiles.

New components, methods of assembly and packaging, and the transistor all indicate that the electronic era is coming up with the answers to the problems of reliability, size, weight, and power requirements. Operational stability is rapidly approaching a point where maintenance of the electronic equipment installed and used in routine operational aircraft does not require more highly skilled personnel or more frequent attention than other parts of the aircraft system.

Review of present and projected planning for air navigation aids and systems indicates that the use of telemetering and radio control systems and techniques has not been and apparently is not being presently considered or included in these programs. It is believed that, if an objective re-evaluation might be made at an early date, the use of telemetering systems and techniques may provide both useful and logical tools leading to simplified and more reliable air navigation systems. These potential new systems employing telemetering techniques could provide for greater in-flight safety by virtue of the fact that both the aircraft crew and ground control facilities may, for the first time, have all necessary flight and performance information available for optimum operation. In addition, operational telemetering may be used to supplement the usual "check-off" list and thus aid the pilot and air crew in carrying out routine operations by precluding missetting and misreading or interpretation of critical data.

Air navigation has certain problems unique to this medium of travel. While travel through, or on, fluid bodies subject to flow current perturbation is a problem common to both aircraft and water-borne commerce, it is only the aircraft that has a high rate of response, and, generally speaking, only the aircraft encounters an immediate crisis in event of loss of power or integrity of the vessel surface.

The flight path (true course, ground speed, and altitude) of an aircraft may be determined from the ground by means of radar. For optimum control and navigation of an aircraft over a fixed course with the proper air speed and in a fixed time, these factors are but several of a number of factors which must be taken into account. True air speed, heading, power, rate of fuel consumption, and balance of fuel remaining are the other essential information elements available only in the aircraft, while surface wind velocity and direction are available only on the ground.

In the past and at the present, the information available, as outlined above, is assimilated by the aircraft crew, coordinated with Air Traffic Control and/or Air Approach Control as required, and the flight then conducted accordingly.

For an isolated aircraft operating in low-density traffic and further qualified as an aircraft with an adequate supply of fuel remaining and relatively low air speed, this information and information utilization system is generally adequate. For high-density traffic and/or high-speed traffic in aircraft with more marginal fuel supplies, rapid assimilation of all of this information will finally tax the aircraft crew to the limit of their human capabilities until it will ultimately become necessary to provide a computer specifically built to assimilate rapidly and utilize efficiently this informa-

Presented at the Electronics Session, Twenty-Second Annual Meeting, IAS, New York, January 25–29, 1954.

* Chief Engineer, Tuner Division.

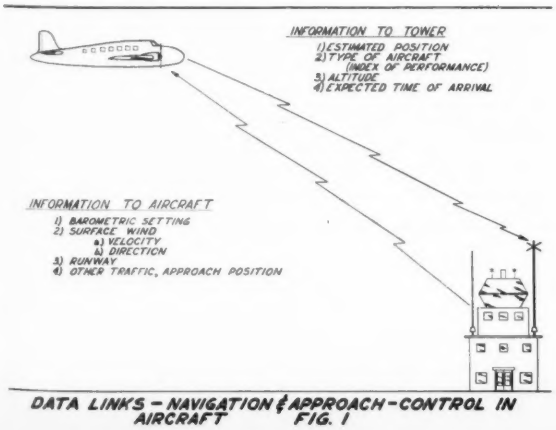
tion. At present the aircraft crew is the computer and data storage and data assimilation system.

When more than one aircraft is involved, the problem becomes even more complex because navigation of two aircraft to a common destination will require rationalization of all this same information for each aircraft, plus the making of a final decision based upon physical factors existent only at the intended destination. These latter factors will include surface wind velocity and direction, temperature (and perhaps barometric pressure) data: altitude, runway lengths, runway directions, etc. Under a complex system as visualized above, there are two approaches that will provide a satisfactory solution. In one, each aircraft has its own computer receiving information from the destination and the other aircraft; in the other, a ground computer receives information from each aircraft, feeds in data relative to all factors of the intended destination field area, and then sends out the necessary control information or command signals to bring in properly each aircraft to the destination (or alternate) landing field.

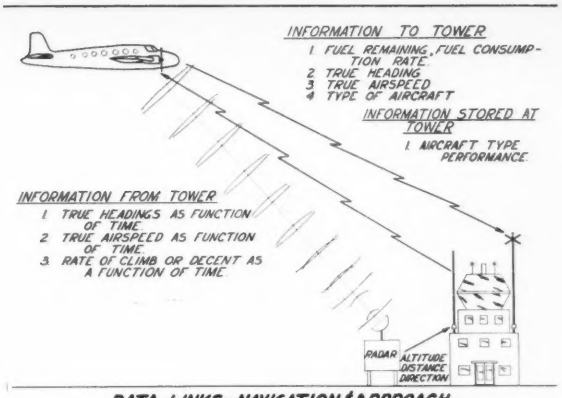
Fig. 1 outlines the data and data sources required in the aircraft for navigation and approach purposes—the data required to evaluate the time of arrival, rate of fuel consumption, and proper approach speed.

Fig. 2 outlines the data and data sources required on the ground for navigation and approach purposes if assimilation and control information is to be given to the air crew for utilization.

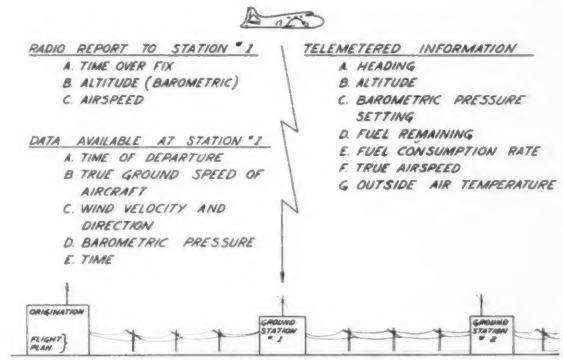
In both Figs. 1 and 2, it will be noted that in each case some quantitative information must be transmitted via a radio link, either from the ground to the aircraft or from the aircraft to the ground. In the first case, as shown in Fig. 1, the air crew must constantly check the course made good and the fuel consumption rate. Command control of the aircraft by the air crew is then predicated upon utilization of the foregoing information, and the subsequent flight path is carried out at the rate projected as optimum with due consideration given to the Air Traffic Control and Air Approach Control requirements. Fig. 2 differs from Fig. 1 in that all computation is now carried out



DATA LINKS – NAVIGATION & APPROACH – CONTROL IN AIRCRAFT FIG. 1


INFORMATION TO TOWER
1. FUEL REMAINING, FUEL CONSUMPTION RATE
2. TRUE HEADING
3. TRUE AIRSPEED
4. TYPE OF AIRCRAFT
INFORMATION STORED AT TOWER
1. AIRCRAFT TYPE PERFORMANCE
INFORMATION FROM TOWER
1. TRUE HEADINGS AS FUNCTION OF TIME
2. TRUE AIRSPEED AS FUNCTION OF TIME.
3. RATE OF CLIMB OR DECENT AS A FUNCTION OF TIME
RADAR
ALTITUDE DISTANCE DIRECTION

DATA LINKS – NAVIGATION & APPROACH – CONTROL ON GROUND FIG. 2

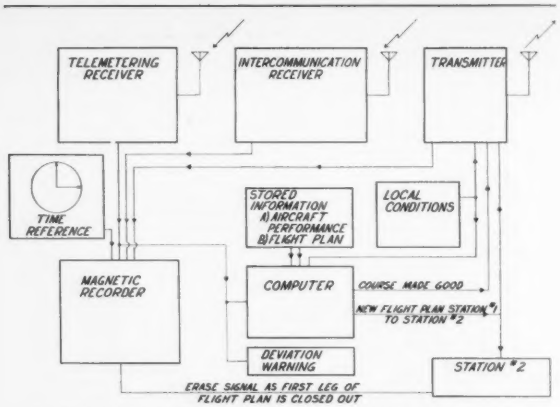


OPERATIONAL TELEMETERING FLIGHT CONTROL FIG. 3 A

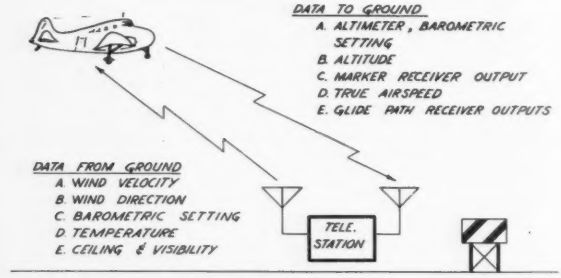
on the ground with the required command signal information relayed to the air crew for proper command control of the aircraft.

Next, consider some potential and perhaps more immediate areas in which telemetering might be profitably employed as an aid to air navigation. The filing of an A.T.C. flight plan and A.T.C. control of the flight along the airway with the aircraft periodically, reporting its progress at previously designated check points, is not an uncomplicated procedure. Both personal experience and hangar flying sessions with friends have indicated that, under certain circumstances, an understandable failure in the human link of information resulted in a "lost" flight. With reduced budgets, plus expanding air commerce, it will be even more essential that every effort be made to minimize the ever increasing man power requirements by providing automatization wherever possible, thus most economically delegating routine calculation and analysis to machines while preserving the ratiocination talents of men for the essential tasks that can be provided only by man. Concurrent with such a step, routine "human" errors will be reduced to the vanishing point, and automatic, most economic operation will become axiomatic.

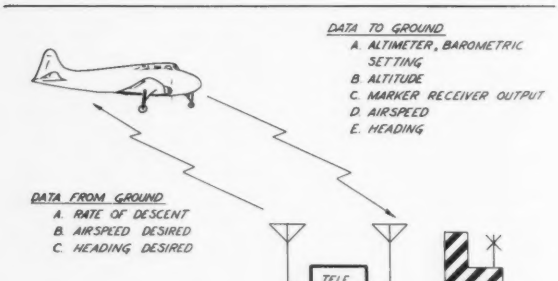
Figs. 3A and 3B outline a rudimentary telemetering flight control system as I originally proposed in



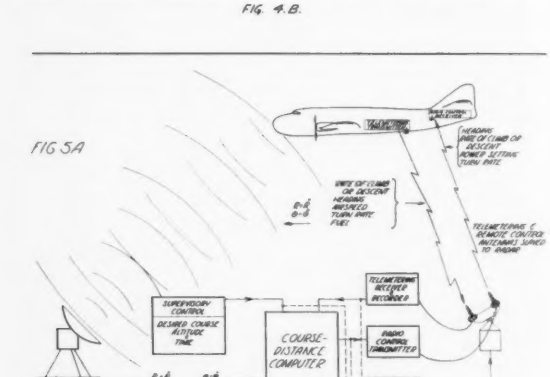
OPERATIONAL TELEMETERING FLIGHT CONTROL
FIG. 3B



OPERATIONAL TELEMETERING - ILS UTILIZATION
FIG. 4.A.



OPERATIONAL TELEMETERING - GCA UTILIZATION
FIG. 4.B.



OPERATIONAL TELEMETERING · CLOSED LOOP · RADIO COMMAND CONTROL

a paper presented before a joint IAS and RAeS conference in London in 1947. Each ground station shown in Figs. 3A and 3B would consist of radio receiving equipment for the telemetering signals, a continuous magnetic tape recording system, suitable telemetering decoding equipment, radio transmitting equipment, a time reference, and a simple computer for computing the true groved speed from the preceding station and projecting the next leg of the flight plan from this information reconciled against present wind velocities and directions.

For unattended automatic control, prerecorded tape may be used to transmit aural information from the ground station to the crew of the en route aircraft. The flight plan, filed prior to take-off of the aircraft, would have been transmitted to the ground station via wire, microwave, or radio link. As the aircraft passes the check point, information as to the aircraft performance would be automatically recorded and decoded at the ground station. The computer would compare this with the originally filed flight plan. The crew of the en route aircraft would then be automatically advised as to the flight's progress and supplied with such supplementary information as desired or required. Simultaneously, a recording will have been made of all aircraft performance data received at this ground station when the aircraft automatically reported in. In the event of inadvertent deviation of the aircraft flight path, or variation in performance of the aircraft power plants, etc., from normal operation, this would be immediately and automatically called to the attention of the crew of the aircraft. Eventually, it may be found more practicable to send back direct flight advisory information in the form of repeat-back instrument readings rather than go through an intermediate aural link.

Telemetering techniques could become most useful as an aid in the Approach Control problems. Current surface and area wind conditions and direction will always be of interest and importance to the air crew during an I.L.S. approach. Equally important, the true air speed, indicated altitude, and the aircraft heading should be available to G.C.A. personnel controlling an aircraft for that type of approach.

Figs. 4A and 4B outline the potential use of telemetering in both the I.L.S. and G.C.A. cases.

Again it is pointed out that operational telemetering as outlined in Fig. 4A might be used as an automatic, unattended operation. In a sample system, a prerecorded magnetic tape would be fed into an aural communications channel upon interrogation (on a normally guarded channel). The properly selected section of the prerecorded tape would be selected by sensing instrumentation on the ground. A more efficient utilization system would by-pass the stored magnetic information and directly transmit the measured quantities by telemetering.

Air navigation presents its biggest problems at a terminal where weather conditions require complete instrument approaches and landings. Here, however,

I.L.S. and G.C.A. assist in and provide a partial solution to the problem. An even more complex but more efficient air traffic handling system is the new Air Force VOLSCAN that presents an integrated traffic handling system rather than a single element system as represented by I.L.S. and G.C.A. techniques. It is, of course, realized that A.S.R. as used with G.C.A. does present the general approach pattern. However, the use of G.C.A. with A.S.R. is obviously inadequate when a large number of high-speed aircraft is involved at a high-density terminal. High-density traffic systems will require tight control and will consequently necessitate a closed-loop control system.

Fig. 5A outlines the basic system elements of such a closed-loop system. A radar set is employed to a measure range and range-rate, train and elevation angles, and rate of change of these angles. From this information the altitude, course, and the speed may be determined by means of a relatively simple computer.

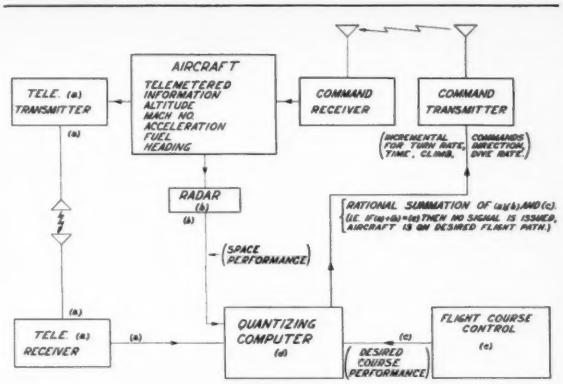
Fundamental information is simultaneously transmitted from the aircraft to the ground station by means of telemetering signals. This information will give the true heading, true air speed, etc., and will also advise as to the fuel remaining and fuel consumption rate. These latter two pieces of information would be used in the system computer in order to evaluate and determine the optimum landing sequence of the aircraft in the approach pattern.

Slaved to the radar will be two highly directive antennas—one for the telemetering receiving link, the other for the radio command system. It is likely that these antennas may be required to be located at some distance from the radar equipment, and, accordingly, a simple type of parallax computer would be employed.

In the system of Fig. 5A the approach control operator (or an approach control system such as VOLSCAN) will assign the closed-loop servo-control unit to an aircraft. The computer output will then feed in appropriate command signals that will designate the course and pattern to be followed in making the landing. Available and stored in the computer will be information as to the flight characteristics and performance of the aircraft under control. Also fed into this computer will be information as to the surface wind velocity and direction and runway length and direction.

With the above information, the computer will rationalize the data and transmit the appropriate command signals to the aircraft via the radio control command transmitter. This is a closed-loop servo system that will permit an accurate automatic approach and landings under any and all ceiling and visibility conditions.

It is interesting to note that the new Air Force control system VOLSCAN would provide an excellent tie-in with an operational telemetering system because a relatively complete computer is already a basic part of the system. Again it is pointed out that, while the VOLSCAN unit can and will evaluate the true ground



"QUANTIZED, INCREMENTAL COMMAND" SYSTEM
FIG. 5B

speed and true course, it cannot give the true heading or the true air speed of the aircraft. (Consequently, a considerable safety margin must be allowed for approach navigation that accordingly restricts the load carrying capabilities of the system to approximately 120 arrivals and departures per hour.) An indirect tie-in with operational telemetering in the VOLSCAN system (using aural radio communication) indicates that the utilization could be increased approximately 50 per cent as a result of the fact that true air speed and heading are now available which thus permits a tighter pattern. With these same factors available to the VOLSCAN computer via operational telemetering, an approximate 100 per cent increase in utilization would be entirely practical if automatic, servo tie-in is utilized with this system.

Fig. 5B is a block diagram of a system designated a "quantized, incremental command system." This system is essentially the block diagram of the pictorial system of Fig. 5A. As previously pointed out, each telemetering transmission is capable of supplying a large amount of information in a short period of time, and, by the same token, each radio command signal may similarly transmit a large amount of information per unit time. In view of the fact that the utilization rate of this information by both the air-borne equipment and the ground equipment is relatively slow, the information may be stored up in each location and then utilized as required. Because of the fact that the

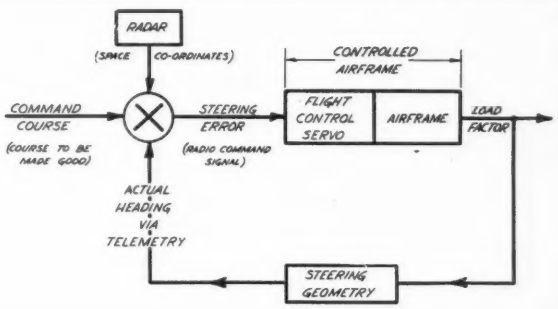
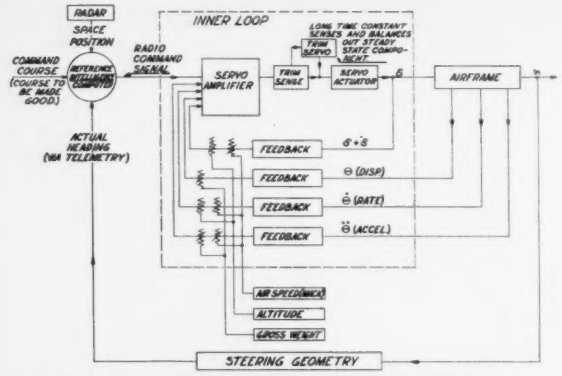


FIG. 5.C. FUNCTIONAL SYSTEM STABILIZATION LOOP



SINGLE AXIS, FUNCTIONAL SYSTEM, STABILIZATION ELEMENTS FIG. 5D

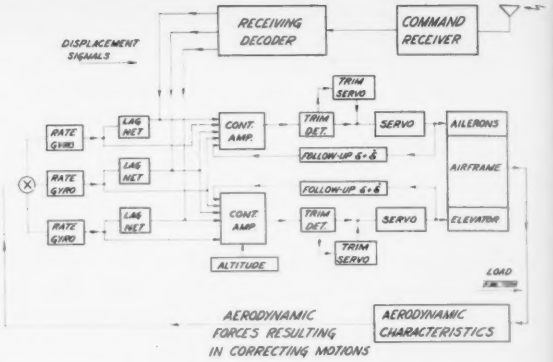


FIG. 5.E. FUNCTIONAL BLOCK DIAGRAM - STABILIZATION AND CONTROL SYSTEM

electronic rationalization process requires and utilizes a discrete interval of time after which appropriate command signals are transmitted via the radio command control link to the aircraft, the radio command signal will call for some specific performance of the aircraft for a finite period of time. For example, a typical signal may call for a reduction in altitude at a rate of 300 ft. per min. for 30 secs. It is thus apparent as to why this system was given the name of a "Quantized, Incremental Command System."

Fig. 5C is a block diagram of the stabilization loop of such a system. Fig. 5D outlines the elements of a single-axis, control link. Fig. 5E is a system block diagram of a two-axis stabilization and control system (not including power plant, flap, or spoiler system) which may be used as a part of the overall system outlined above. It is to be noted that this is a rate-controlled and stabilized system that presents many desirable characteristics from the standpoint of reliability and ruggedness.

Next consider the equipment and frequency allocation problems.

The use of radio control and telemetering information, carried as additional subcarrier frequencies on the radio control channel, is even more interesting in that magnetic recording equipment used for receiving and storing either of these signals intrinsically provides a correlated time and performance record along with the complete radio contact information on the flight.

If D.M.E. equipment, or its finally agreed upon counterpart, is adapted and tied into such a system, the problems of ground control are again simplified and the use of the more complex control radar system may be eliminated. This technique would put more of the flight responsibility back on the air crew while reducing the cost and complexity of the Government-operated facilities along the airway and at the air terminals.

The frequency allocation problem has been reviewed and several problems present themselves.

In high-density traffic areas the allocation of a separate frequency for each aircraft is obviously precluded because of the limitation of the number of channels which may be handled by ground facilities, as well as the channel limitations and equipment handling capabilities of the air-borne elements in this system.

It is fortunate that telemetering and remote control systems can transmit, receive, and utilize information at relatively high rates of speed as compared to the frequency response and performance characteristics of the aircraft and the air crew controlling the aircraft. This means that a large amount of telemetering and control information may be sent and received (and stored for future reference) in a short period of time. Because the air crew and aircraft cannot immediately utilize all this information, it may seem that this stored information could be utilized without the need of a continuous radio channel. Under such conditions, intelligence transmissions from the aircraft and from the ground station may be carried on an additional supersonic, subcarrier frequency (or frequencies) of the radar, tower, range, and/or approach control radio channels.

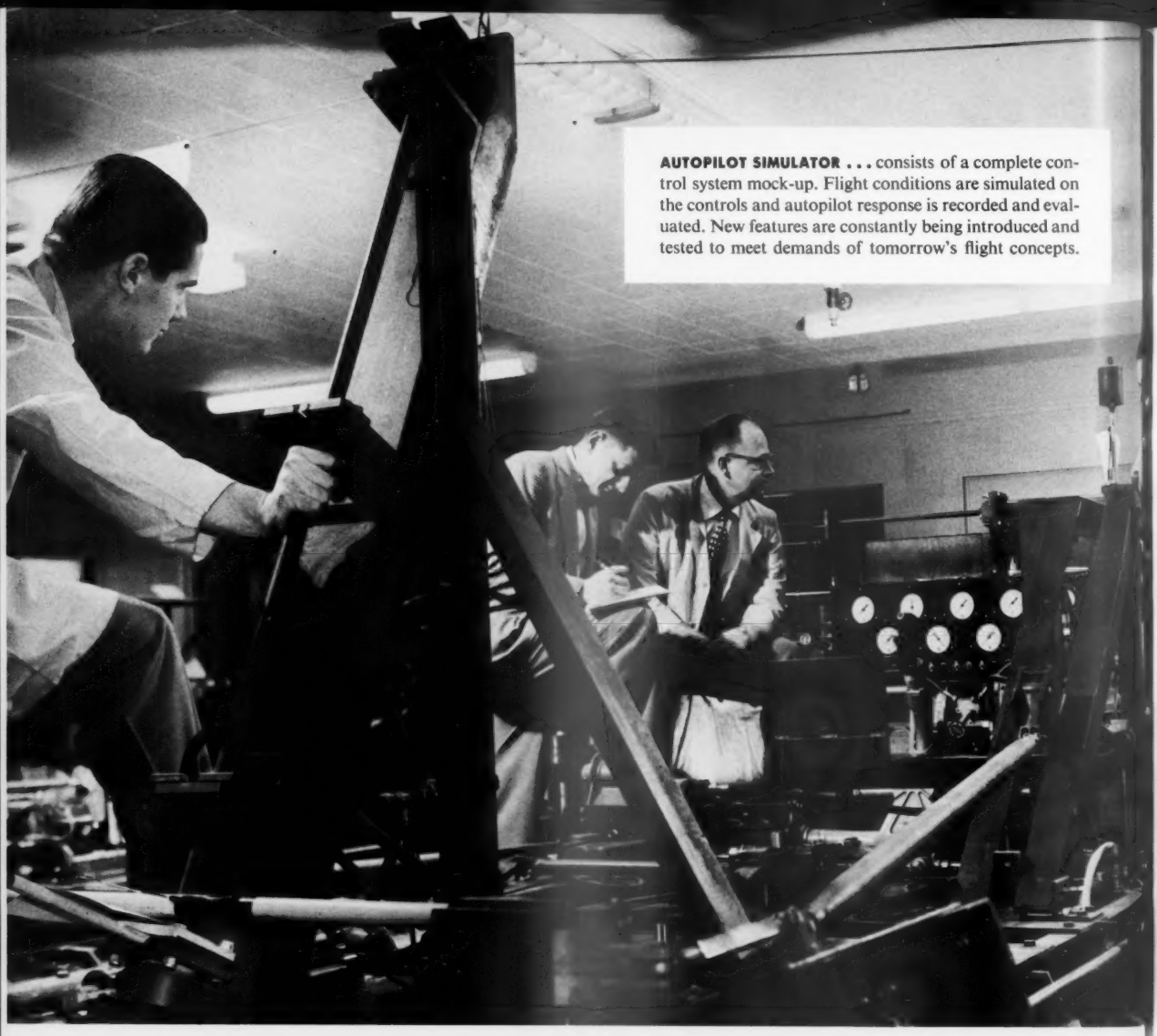
There are a number of other tenable frequency allocation solutions; however, the supersonic subcarrier system appears to be the one approach presently available to an operational telemetering system.

The rate automatic pilot . . . only system to give unlimited maneuverability, precise control at high speeds

Westinghouse automatic flight control systems represent the most advanced state of the art in the autopilot field. The W-3 and E-9 automatic pilots make completely automatic flight *fact* instead of *fancy*. Developed, flown and now being produced for military jet fighters, they are the first to combine the rate gyroscope and MAGAMPS into a packaged system which is lightweight, compact and completely proved.

The use of the rate gyro makes possible a new degree of precise control and maneuverability not possible with position gyros. MAGAMPS are extensively used to give the rate automatic pilot reliability superior to other types of similar equipment.

FIND OUT WHY . . . ON THE FOLLOWING PAGES ➧

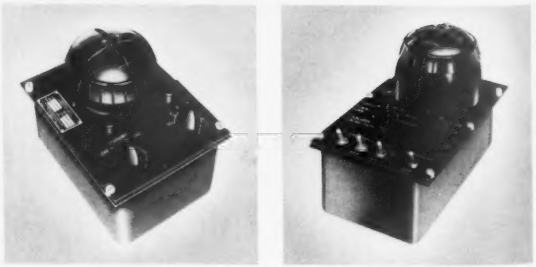


AUTOPILOT SIMULATOR . . . consists of a complete control system mock-up. Flight conditions are simulated on the controls and autopilot response is recorded and evaluated. New features are constantly being introduced and tested to meet demands of tomorrow's flight concepts.

Only production automatic pilot to use rate gyros . . .

Modern, high-speed aircraft, because of aerodynamic requirements, often suffer from poorly damped natural oscillations—they are inherently unstable. The sensing elements which detect these oscillations and provide the "intelligence" to eliminate them is the rate gyroscope. By developing a rate gyro and applying it to the E-9 and W-3 systems, Westinghouse has elevated the automatic pilot to the vitally important tactical role of a completely automatic, integrated flight control system.

The rate gyro will not tumble, and provides instantaneous response to external disturbances and attitude changes. Using rate gyros in all three axes—roll, pitch, and yaw—Westinghouse rate automatic flight control systems can maneuver an aircraft quickly and smoothly, as well as provide "platform" stability.



These are the pilot's consoles of the E-9 and W-3 Rate Automatic Pilots. Controls are human engineered to achieve simplicity of operation. The W-3A has provision for radar coupling and ILS tie-in, making the autopilot serve a vital new role in automatic flight control.

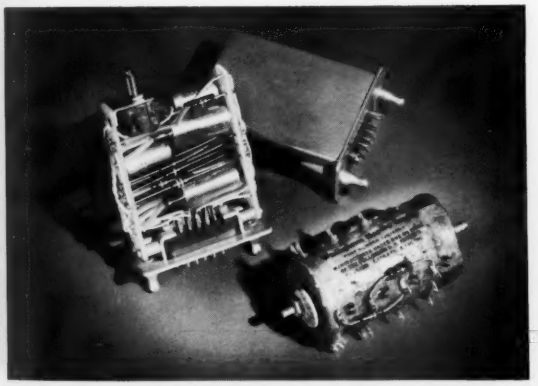
THE SCOPE OF WESTINGHOUSE IN AVIATION

Jet Propulsion • Airborne Electronics • Aircraft Electrical Systems and Motors • Wind Tunnels to Plastics

Magamps improve reliability, decrease weight . . .

The MAGAMP (magnetic amplifier)—a Westinghouse exclusive—is used to make the rate automatic pilot a new standard of dependability. As simple and reliable as iron and copper, MAGAMPS are rugged replacements for vacuum tubes. MAGAMPS operate directly from the ac supply voltage and require no filament current, hence have a greatly reduced cooling requirement. Greater component life is inherent in the transformer-like construction of MAGAMPS. Wherever used, they give systems added value with their reliability and long life.

These features make the Westinghouse rate automatic pilot far more dependable. Maintenance requirements are reduced, circuitry is simplified and these full-time automatic flight control systems can be depended upon to perform under all types of operating conditions.



MAGAMPS and Potted Units are two refinements developed by Air Arm to give electronic systems exceptional reliability and ease of maintenance. MAGAMPS are a Westinghouse development using specially wound cores, printed circuits and Fosterite® impregnation to protect against all atmospheric conditions, and improve heat dissipation and dielectric properties.

• • •

Air Arm facilities now producing rate automatic pilots . . .

Rate automatic pilots are being produced in quantity at the Westinghouse Air Arm Plant. The W-3 system—now flying in an Air Force all-weather interceptor—includes an ILS (instrument landing system) tie-in for automatic, "hands-off" approach to a field in low visibility weather. Soon to come for the W-3 system is a radar tie-in, which means that the automatic pilot will take commands directly from the fire control system and automatically fly the interceptor on a computed intercept course . . . for what might be termed an automatic kill.

Airborne equipment must be as precise as a watch and as rugged as a steam roller. Fabricating such equipment and tailoring it to an airplane is not just a matter of taking measurements and cutting to a pattern—it requires real know-how and experience.

• • •

Today's answer for tomorrow's problem . . .

Experience has shown that in our business no problem ever stays solved. The requirement of building a better system is always with us. To meet the ever-increasing requirements of high-speed automatic flight, our development labs are at work, creating the advancements for tomorrow's flight systems. Thus, Air Arm is helping to bring Tomorrow's Aircraft . . . One Step Closer. Westinghouse Electric Corporation, Air Arm Division, Friendship International Airport, Baltimore, Md. J-91015

Component of Westinghouse Rate-Type Autopilot is shown here being bench tested. This is part of the Air Arm program which guarantees that every unit will meet rigorous military specifications. Ability to produce and qualify complete systems under one roof means more defense for the defense dollar.

YOU CAN BE SURE...IF IT'S

Westinghouse

ENGINEERS ...our new brochure tells wh

Westinghouse is a career ...

The Air Arm Division offers a variety of challenging opportunities, available as a result of our long-range expansion program in the aviation-electronics field.

Many engineers are already building for themselves key positions in the organization that has produced some of the country's most advanced scientific developments. Current openings offer a variety of challenging problems requiring engineers with a high degree of originality and ingenuity. Excellent ground-floor opportunities exist for men from the B.S. to Ph.D. level.

A few of the many exceptional advantages of a career with Westinghouse:

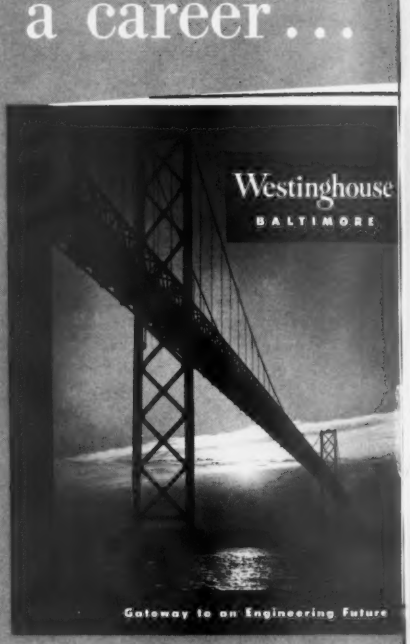
Professional recognition and industrial stability.

Opportunities, at company expense, for advanced degrees.

Exceedingly liberal patent disclosure compensation.

Salaries individually determined according to experience and ability.

Promotion on basis of individual merit.



Send Today for

your copy of "Gateway to an Engineering Future."

Electrical Engineers **Mechanical Engineers**
Physicists **Mathematicians**
Field Service Engineers

YOU CAN BE SURE ... IF IT'S

Westinghouse

AIR ARM DIVISION

Mr. R. M. Swisher, Jr.
Employment Supervisor, Dept. A
Westinghouse Electric Corporation
109 West Lombard Street
Baltimore 1, Maryland

Please send me a copy of "Gateway to a Engineering Future."

Name.....

Address.....

City.....State.....

Engineering Field.....

IAS NEWS

(Continued from page 52)

Earl P. Osborn, AFIAS, Chief, Applied Loads Section, Structures Department, Grumman, was reappointed to the Subcommittee on Aircraft Loads.

Mundy I. Peale, AMIAS, President and General Manager, Republic, was appointed Chairman of the Industry Consulting Committee.

Dr. Ernest E. Sechler, AFIAS, Professor of Aeronautics, CalTech, was reappointed a member of the Subcommittee on Aircraft Structures.

William I. Stieglitz, AFIAS, Design Safety Engineer, Republic, was reappointed to the Committee on Operating Problems and to the Subcommittee on Aircraft Fire Prevention.

Charles Tilgner, Jr., AFIAS, Chief, Aerodynamics and Flight Test, Grumman, was appointed to the Committee on Aerodynamics.

William M. Zarkowsky, MIAS, Chief, Power Plant Aerodynamics, Grumman, was named to the Subcommittee on Internal Flow.

Aviation Crash Injury Research Joins Cornell-Guggenheim Aviation Safety Center

Aviation Crash Injury Research has joined and is now operating as a unit of the Cornell-Guggenheim Aviation Safety Center, of which Jerome Lederer, FIAS, is Director. A. Howard Hasbrook, who was Administrator of Crash Injury Research's Aviation Research at the Cornell University Medical College, is now Associate Director of the Center and is in charge of the activities of the Aviation Crash Injury Research.

An Advisory Council, consisting of Hugh De Haven, AFIAS, Dr. Wilson G. Smillie, and Dr. Emerson Day, represents and provides continued affiliation with Cornell Medical College. Mr. De Haven, Founder and Director of Crash Injury Research, continues as Director of Automotive Crash Injury Research at the medical college.

Funds for the Aviation Crash Injury Research are currently provided by the U.S. Departments of the Navy and Air Force, under the Office of Naval Research; the ONR contract is administered by Cornell University.

All inquiries that have formerly been addressed to the Aviation Division of Crash Injury Research should now be made to Aviation Crash Injury Research, Cornell-Guggenheim Aviation Safety Center, 471 Park Avenue, New York 22, N.Y. The telephone number at this Park Avenue address is PLaza 9-7690.

Automatic Control Courses Announced

Two Intensive Courses in Automatic Control have been announced by the University of Michigan, College of Engineering. These courses, designed for the engineer who finds it necessary or who wishes to obtain a basic understanding of the field, are scheduled for June 14–19 and June 21–23.

The courses are built around the principles and application of measurement, communication, and control. Course I will consist of the fundamentals in each of these fields and will include some fundamental work in nonlinear systems. Course II will take up applications of the fundamental to more advanced problems.

Further information may be obtained by writing to Prof. M. H. Nichols, Room 1523, East Engineering Building, University of Michigan, Ann Arbor, Mich.

Necrology

Robert O. Bitner

Robert Owen Bitner, TMIAS, died on December 27 at the age of 34.

A native of Waynesboro, Pa., he was a student at The Pennsylvania State College (now University) from 1936 to 1939. In 1941 and 1942, he was enrolled in the U.S. Air Corps Technical School. Four years later, in 1946, he matriculated at the Spartan College of Aeronautical Engineering and was awarded an Associate in Arts degree by the school in March of 1948.

Mr. Bitner had been a Machinist at Jacobs Aircraft Engineering Company for the 9 months prior to his entering the U.S. Army Air Force in October, 1941. During his 5 years in the Air Force, he served as an Aircraft Maintenance Officer. He received his military discharge in March, 1946, becoming a member of the USAF Reserve with the rank of Lieutenant Colonel.

In June, 1948, he went to work for The Glenn L. Martin Company as a Senior Draftsman. His last known position before his death was an Engineer in the Operations Branch, Propulsion Wind Tunnels, Arnold Engineering Development Center.

Mr. Bitner is survived by his widow, Joyce M. Bitner.

Henry H. Budds

Henry Harold Budds, AMIAS, President of Budds Aero Castings, Inc., died on February 18.

Born in Pana, Ill., on July 5, 1903, Mr. Budds attended Pana High School and subsequently Barking Trades Training Center in London, England. From 1919 until about 1940, he was employed in the automobile-body manufacturing field in various supervisory capacities. The firms included Hayes Manufacturing Company, Michigan Stamping, Briggs Manufacturing Company, and Briggs Motor Bodies (England).

The British automotive firm, in addition to building automobile bodies, etc., also made airplane parts and assemblies for the Halifax and Hamdon bombers and the Kestrill trainer. There, Mr. Budds served as Manufacturing Manager. Upon returning to the United States in 1940, he became General Manager of Briggs Manufacturing Company's Conners Aircraft Division. He organized his own firm some time later.

John C. Newton

John C. Newton, MIAS, Project Engineer with Specialties, Inc., died on January 19.

Born in New York City on November 17, 1904, he attended the Flushing (N.Y.) High School and Brown University. He received his B.Sc. degree in Electrical Engineering from Brown in 1928. At a later date, he took special courses in geology and metallurgy at the University of Arizona.

In 1929 and 1930, Mr. Newton was a Student Engineer with General Electric Company. The following year, he went to work for the New York City Board of Transportation as a Power Dispatcher for the Independent subway line. Eight years later, he became Assistant Product Engineer at Sperry Gyroscope Company, Division of The Sperry Corporation, and in 1941 was appointed a Project Engineer at Sperry. In 1950, he became associated with Specialties, Inc.

Mr. Newton, who held four patents concerned with boosters or autopilots, is survived by his widow, Leah M. Newton.

News of Members

▸ **Humberto Delgado** (M), of the Portuguese Air Force, has been promoted to the rank of Major General. General Delgado is Chief of the Portuguese Military Mission in Washington, D.C.

▸ **François N. Frenkiel** (AF), Applied Physics Laboratory, The Johns Hopkins University, Silver Spring, Md., has been named the 1954 Chairman of the Executive Committee of the American Physical Society's Division of Fluid Dynamics.

▸ **Hans W. Liepmann** (F), Professor of Aeronautics, California Institute of Technology, has been appointed a member for 1954 of the Executive Committee of the American Physical Society's Division of Fluid Dynamics. Professor Liepmann was the Chairman of this committee during 1953.

▸ **Edward Mosehauer** (M), Chief Design Engineer, Hamilton Standard Division, United Aircraft Corporation, has been reassigned and is now heading the joint design and drafting activities.

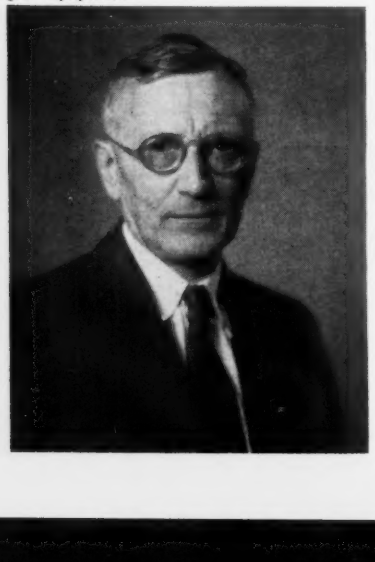
▸ **Thomas B. Rhines** (M), Assistant Chief Engineer, Hamilton Standard Division, United Aircraft Corporation, has taken over the duties vacated by Carl F. Baker (q.v., Members on the Move) and is now handling engineering problems of the older and more established products.

▸ **Joseph Solvey** (M), Principal Scientific Officer, Aeronautical Research Laboratories, Australia, is on temporary assignment at the Royal Aeronautical Society, London, England. This appointment is for the period of 1 year.

▸ **Juan T. Trippe** (AM), President, Pan American World Airways, Inc., was recently honored by the governments of Columbia, Honduras, and Panama for his leadership in developing commercial aviation in Latin America. The Honduran government decorated Mr. Trippe with the Order of the Honduran Air Corps Wing (Ala del Cuerpo) with citation. Panama decorated him with that country's Order of Vasco Nunez de Balboa, Rank of Commander. Columbia, which had made Mr. Trippe a Knight of the Order of Boyaca in 1952, raised him to the higher rank of Commander of that order.

▸ **Leo A. Weiss** (TM), President, Aviation Engineering Division, Avien-Knickerbocker, Inc., has been named a Vice-President of the newly formed Control Laboratories, Inc., Valhalla, N.Y. This company is associated with Aviation Engineering (q.v., Corporate Member News).

Dr. William G. Brombacher, an IAS Fellow and Founder Member, retired as Chief of the Mechanical Instruments Section, National Bureau of Standards. Dr. Brombacher, who joined the NBS in 1919 after receiving his Ph.D. degree from The Johns Hopkins University, had been an NBS Section Chief since 1926 when he was appointed Chief of the Aeronautical Instruments Section, the predecessor of the Mechanical Instruments Section. Dr. Brombacher is considered one of the country's leading authorities on mechanical instruments, especially in the fields of pressure and humidity measurements, aeronautical instruments, and air-borne oxygen equipment.



Members on the Move

The purpose of this section is to provide information concerning the latest affiliations of IAS members. All members are therefore urged to notify the News Editor of changes as soon as they occur.

Harold T. Avery (M), Vice-President—Engineering, Marchant Calculators, Inc. Formerly, Chief Engineer, Marchant.

Carl F. Baker (F), Quality Manager, Hamilton Standard Division, United Aircraft Corporation. Formerly, Chief Engineer, Hamilton Standard.

Myron G. Beard (F), Vice-President, Equipment Development, American Airlines, Inc. Formerly, Chief Engineer, American.

Gregory J. Brandewiede (M), Vice-President, Purchasing and Stores, American Airlines, Inc. Formerly, Vice-President, Maintenance and Supply Department, American.

Joel E. Brown (M), Senior Flight Test Engineer, Aerophysics Laboratory, North American Aviation, Inc. Formerly, Aerodynamicist, Santa Monica Division, Douglas Aircraft Company, Inc.

Elliot Daland, an IAS Associate Fellow and Founder Member, has resigned as Vice-President of Piasecki Helicopter Corporation. Mr. Daland's resignation marks only a partial retirement, since he is continuing with Piasecki as an Engineering Adviser. Mr. Daland has been active in the aircraft industry for the past 37 years as a designer, engineering executive, and manufacturer.

Major William S. Dawson, USAF (AM), Wing Communications-Electronics Officer, 407th Strategic Fighter Wing, Strategic Air Command, Great Falls AFB, Mont. Formerly, Wing Training Officer, 1300th Air Base Wing, Military Air Transport Service, Great Falls AFB, Mont.

Paul R. Des Jardins (TM), Flight Test Engineer, Aerophysics Division, North American Aviation, Inc. Formerly, Aircraft Equipment Specialist, TC Army Aviation Field Service Office, St. Louis.

Edward H. Farmer (M), Manager, San Jose (Calif.) Manufacturing Plant,

Dr. C. Richard Soderberg, FIAS, became Dean of the School of Engineering, Massachusetts Institute of Technology, on April 1. Dr. Soderberg, who had been Head of M.I.T.'s Department of Mechanical Engineering since 1947, was first appointed to the M.I.T. faculty in 1938 as Professor of Applied Mechanics and 4 years later was named Professor of Mechanical Engineering. Before coming to M.I.T., Dr. Soderberg was Manager of the Turbine Division of Westinghouse Electric Corporation.

RESEARCH KEEPS **B.F.Goodrich** FIRST IN RUBBER

Boeing B-52 to land on strongest high-speed tire yet developed

THE B-52 heavy bomber has a gross weight of over 350,000 pounds. To land it at high speeds, the Air Force needed a tire that could take terrific impact and heat. A tire that greatly exceeds B-52 requirements and could take 50 landings at 200 mph on the dynamometer without failure. It was one of the toughest tests ever set for an airplane tire.

B. F. Goodrich engineers tackled the assignment. Using new techniques and rubber compounds, they came up with the largest capacity high-speed tire yet developed. It not only passed the "50 landings" test but was good for still more. And it passed maximum load-capacity dynamometer tests at low speeds. Cut apart for a post-mortem, it revealed *no sign* of failure. Result: the new BFG high-speed tire won official approval, is now being produced for all B-52's.

In addition, B. F. Goodrich wheels and Expander Tube brakes were chosen as standard equipment.

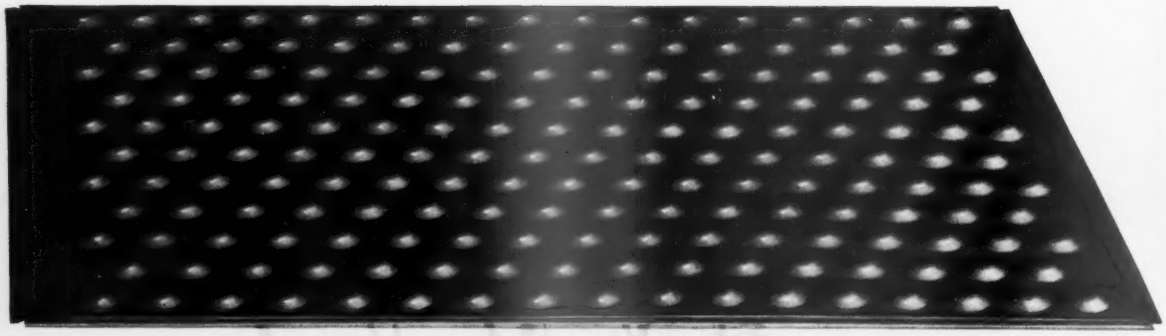
The development of this new B. F. Goodrich high-speed tire is typical of other BFG engineering accomplishments. The first low-pressure airplane tire—the first high-pressure tire—and the first high-pressure tubeless tire were all B. F. Goodrich developments.

Other B. F. Goodrich products for aviation include wheels and brakes, De-Icers, heated rubber, Pressure Sealing Zippers, Avtrim, inflatable seals, fuel cells, Rivnuts, hose and other accessories. *The B. F. Goodrich Company, Aeronautical Sales, Akron, Ohio.*

B.F.Goodrich
FIRST IN RUBBER

6

AN IMPORTANT NEW GEOMETRY FOR



HEAT EXCHANGERS

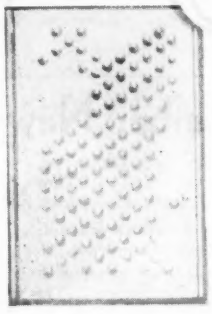
As the performance ceiling of modern aircraft continues to rise, extremes of temperature and pressure in heat generating and in heat exchange equipment create new and challenging problems.

Today's emphasis on heat transfer systems gives particular significance to Janitrol's most recent advance in this field: a new type of "dimple plate" construction which improves efficiency, saves weight, increases strength, simplifies manifolding, and opens a whole new geometry of design.

A complete heat exchanger can now, in effect, be laminated from identical, paper-thin stampings like that shown above. The sheets are welded in pairs, face to face, creating continuous passages for flow of air or liquid—each passage being at right angles to the next, and all passages manifolded in a simple economical design. The indentations increase rigidity of the assembly, facilitate fabrication, and at the same time accelerate heat transfer by creating a desirable turbulence in the flow.

Observe that this new lamination technique permits envelope configurations practically without limit. Now, a high efficiency heat exchange system can be squeezed into spaces previously unusable, and duct or piping connections greatly simplified.

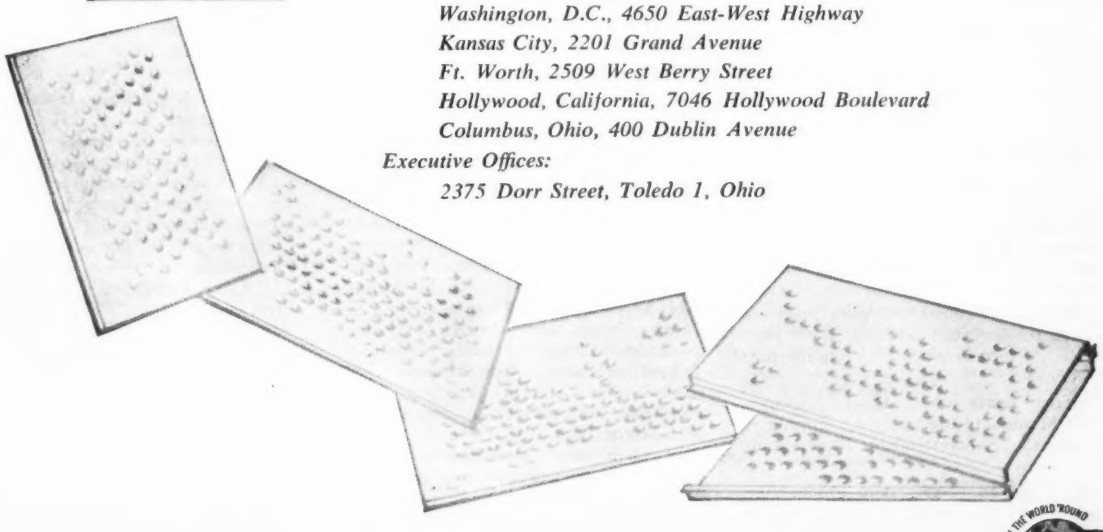
If your heat exchanger problems involve increasingly high temperatures, high pressures, or special space restrictions, you'll do well to investigate this new Janitrol development. In fact, whatever your aircraft combustion problems, your Janitrol representative can place at your disposal Janitrol's thirty-seven years' experience in the manufacture of combustion equipment.



Janitrol®

37 years experience in combustion engineering

National Sales, Engineering, Production Headquarters,
400 Dublin Avenue, Columbus 16, Ohio
District Engineering Offices:
New York, 225 Broadway
Washington, D.C., 4650 East-West Highway
Kansas City, 2201 Grand Avenue
Ft. Worth, 2509 West Berry Street
Hollywood, California, 7046 Hollywood Boulevard
Columbus, Ohio, 400 Dublin Avenue
Executive Offices:
2375 Dorr Street, Toledo 1, Ohio



KNOWN THE WORLD 'ROUND

AIRCRAFT-AUTOMOTIVE DIVISION, SURFACE COMBUSTION CORPORATION • COLUMBUS 16, OHIO

Donald L. Herr, MIAS, a graduate electrical engineer who has designed many electronic and instrumentation systems, is now President and General Manager of Mark Instrument Company, of 613 Wilshire Blvd., Santa Monica, Calif. This organization, co-founded by Mr. Herr the early part of this year, manufactures precision instruments, hardware, equipment, and systems. A brochure listing Markinsco products and services was recently issued by the company.

E. W. Bliss Company. Formerly, Vice-President—Manufacturing, Pacific Airmotive Corporation.

Lawrence G. Fritz (M), Vice-President, Flight, American Airlines, Inc. Formerly, Vice-President, Operations, American.

George Zbigniew Habermass (TM Designer, Aircraft Projects, Hymatic Engineering Company, Ltd., England. Formerly, Development Engineer, Fireproof Tanks, Ltd., England. (Mr. Habermass adopted the Christian name of George when he recently became a naturalized British subject.)

Croydon H. Hartley (M), Sales Director, Servomechanisms, Inc. Formerly, Customer Liaison Director, Westbury, L.I., Division, Servomechanisms.

Colonel Frederick W. Hess (M), Staff Research Physicist and Assistant to the Vice-President, Research and Development, Guided Missile Division, Hughes Aircraft Company. Formerly, Aeronautical Contracts Manager, Hughes Aircraft.

Stuart A. Krieger (M), Vice-President in charge of weapons systems analyses and other studies in field of operations research, Planning Research Corporation. Formerly, Research Engineer, The RAND Corporation.

William Littlewood (F), Vice-President, Research, American Airlines, Inc. Formerly, Vice-President, Engineering, American.

Harry Louis (M), Chief Engineer, Fleet Manufacturing Limited. Formerly, Engineering Superintendent, Fleet Manufacturing.

E. J. Lynch (TM), Test Engineering Supervisor, Aircraft Division, A. V. Roe Canada, Ltd. Formerly, Senior Test Engineer, Avro Canada.

O. M. Mosier (AM), Senior Vice-President and Director, American Airlines, Inc. Formerly, Vice-President and Director, American.

Second Lieutenant Leonard C. Pincus, USAF (TM), Assistant Project Engineer, Structures Branch, Aircraft Laboratory, Wright Air Development Center, Wright-Patterson AFB, Ohio. Formerly, Engineering Trainee, Republic Aviation Corporation.

Edwin F. Potter, Jr. (M), Flight Test Analysis Engineer, Flight Research Department, Sperry Gyroscope Company, Division of The Sperry Corporation. Formerly, Supervisor, Aerodynamic and Weight Unit, Naval Aircraft Factory, Philadelphia.

John H. Quillinan (TM), Aerodynamicist, Lockheed Aircraft Corporation. Formerly, Assistant Flying Qualities Specialist, David Taylor Model Basin, Department of the Navy.

Joe D. Reynolds (TM), Design Engineer "B," Power Plants Group, Temco Aircraft Corporation. Formerly, Sergeant, Instructor, Mechanical Branch Ordnance Guided Missile School, Redstone Arsenal, Ala.

Peter M. Sarles (TM), Midwestern Sales Representative, Aviation Gas Turbine Division, Westinghouse Electric Corporation. Formerly, Flight Test Engineer, Aviation Gas Turbine Division, Westinghouse.

Wilfred H. Shaw (TM), Chief Inspector, Hamilton Standard Division, United Aircraft Corporation. Formerly, Supervisor, Field Service Engineering, United Aircraft Service Corporation, United Aircraft Corporation.

Martin Solomon (TM), Aerodynamicist, Columbus Division, North American Aviation, Inc. Formerly, Aeronautical Research Scientist, Langley Aeronautical Laboratory, NACA.

Thomas M. Sullivan (M), West Coast Representative, Fairchild Engine Division, Fairchild Engine and Airplane Corporation. Formerly, Chief, Field and Installation Engineering, Fairchild Engine Division.

Dr. H. S. Tan (M), with Department of Engineering Mechanics, University of Notre Dame. Formerly, Research Associate, Graduate School of Aeronautical Engineering, Cornell University.

John W. Truran (M), Executive Sales Engineer, Jarry Hydraulics, Division of Jarry Automobile Ltée, Montreal, Canada. Formerly, Special Projects Engineer, Bristol Aeroplane Company of Canada Ltd.

Lieutenant Commander Donald P. Walker, USN (M), Operations Officer and Naval Aviator, Air Anti-Submarine Squadron 26, Atlantic Fleet, USN. Formerly, C-124 Project Engineer and Naval Aviator, Headquarters, Military Air Transport Service, Andrews AFB, Washington, D.C.

Carl R. Wettereau (M), Manager, Test and Handling Equipment Division, Pacific Airmotive Corporation. Formerly, Assistant Chief Engineer, Greer Hydraulics, Inc.

Corporate Member News

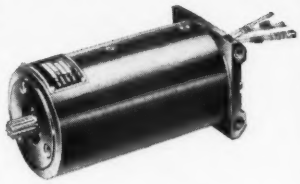
• **Aircraft Radio Corporation . . .** A Type F-12 Filter Assembly has been designed by A.R.C. for use with any signal generator that provides 90/150 cycles per sec. modulation for air-borne VHF glide slope or localizer receiver testing. The use of this F-12 Filter is said to permit the checking of the accuracy of the modulation levels provided by the generator.

• **American Airlines, Inc. . . .** A revised plan of organization to provide for further decentralization of responsibility to the field offices and for better division and definition of departmental responsibility was approved by American's Board of Directors at the February 17 meeting. There are now four principal divisions: Sales, Operations, Finance, and Secretary-Properties, headed by Senior Vice-Presidents Charles R. Speers, O. M. Mosier, AMIAS, William J. Hogan, and C. W. Jacob. Newly elected officers of the company are: Paul G. Larie, Treasurer; Leland Glasgow, Vice-President and Comptroller; Marvin Whitlock, Vice-President, Maintenance and Engineering; and Myron G. Beard, FIAS, Vice-President, Equipment Development. Those already officers of the company but elected to different offices are: R. E. S. Deichler, Vice-President, Customer Service; Lawrence G. Fritz, MIAS, Vice-President, Flight; Gregory J. Brandewiede, MIAS, Vice-President, Purchasing and Stores; Walter Johnson, Vice-President, Properties; and William Littlewood, FIAS, Vice-President, Research.

• **American Phenolic Corporation . . .** A new and improved Blue Ribbon Connector has been developed recently by Amphenol staff engineers. This connector, the company states, "fills a long-felt need for a quick disconnect connector for electronic sub-assemblies where low insertion and withdrawal force is demanded."

• **Aviation Engineering Division, Avien-Knickerbocker, Inc. . . .** A new affiliate, Avien Service Corporation, has been formed for the purpose of handling AVIEN's sales and engineering services at air-frame manufacturers' plants and military installations in the Los Angeles and California areas. The address of the new corporation, of which Leo A. Weiss, TMIAS, is President, is 5423 Sepulveda Blvd., Culver City, Calif. (Mr. Weiss is also President of AVIEN.) Avien Service Corporation is under the direction of Anthony G. Brown, Vice-President. . . . Another company, known as Control Laboratories, Inc., and associated with AVIEN, was also recently formed with offices at Valhalla, N.Y. This particular organization was "planned to be a development facility specializing in the electronic control and servomechanical fields for aeronautical and other industries." Control Laboratories' President is Stanley J. Smith, formerly Director of Engineering and Development at Simmonds Aero-

High Frequency Motor
FOR SPECIAL APPLICATIONS



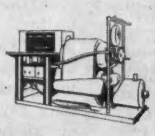
If your project requires a High Frequency Motor, you may match the specification with a Motoresearch unit. We specialize in the design and manufacture of High Frequency Induction Motors and similar equipment. The motor illustrated was developed with a special brake for an Airborne application. Direct current Generators and high frequency Permanent Magnet Alternators, either engine or motor driven, are available from Motoresearch. These units are adapted to applications for Military Services and comply with military specifications.

When your application calls for rotating electrical equipment and standard commercial units do not meet the need, call in Motoresearch, specialists in design and manufacture of electrical equipment. Write, wire or call today.

MOTORESEARCH COMPANY
1600 JUNCTION AVENUE
RACINE, WISCONSIN
Designers and Manufacturers of
SPECIAL INDUCTION MOTORS

United ELECTRICAL TESTING EQUIPMENT

used by the
- AIR FORCE
- ARMY
- NAVY
- AIRFRAME MFR'S
- MAJOR AIRLINES
- COMPONENTS MFR'S

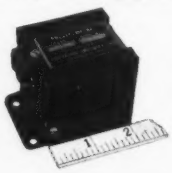


Electrical Components on aircraft, portable power units, ordnance vehicles and guided missiles are being tested rapidly and accurately with United Test Equipment.

Write us your requirements. We specialize in custom design and manufacture.

UNITED MANUFACTURING CO.
Div. UNITED ADVERTISING CORP.
HAMDEN 14 CONNECTICUT

TIMING PROBLEMS?
Electronic Specialty can solve them the modern way — Electronically



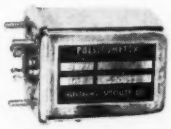
Overheat Warning Flasher

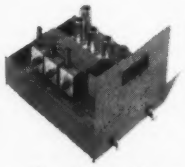
For use in overheat warning circuit of aircraft which use a single warning light for both overheat and fire conditions.

Operating range: 14–30 v.d.c.

15-500 Millisecond Timer

A rugged, sealed, altitude limitless millisecond timer, free from shock and vibration difficulties. 16–30 v.d.c.





Missile Launching Timer

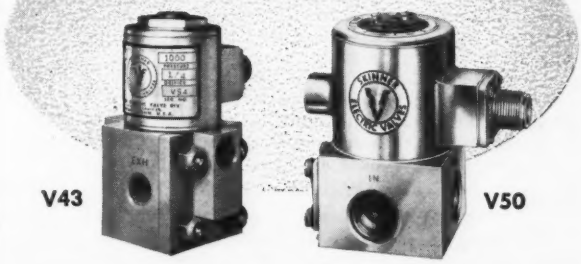
Provides pulses at repetition rate of 1, 10, and 40 per sec. with accuracy of .25% as time base for launching guided missiles.

Sensitometers—Pulsitometers—Regulometers

Send us your requirements

Electronic Specialty Co.
CONTRACT DIVISION
3456 Glendale Blvd., Los Angeles 39, Calif.

SKINNER
high pressure aircraft valves



V43 V50

EXCEPTIONALLY FAST • CUSTOM-BUILT
(opening or closing times under 10 milliseconds!)

Skinner offers you these high-speed solenoid valves — and adapts them to your precise requirements! They are lightweight — yet have large capacities — and are engineered to strict aircraft standards. Both have aluminum bodies, stainless steel internal parts, and Kel-F or Nylon orifice seals. Either continuous or intermittent duty coils can be supplied.

V43 SPECIFICATIONS: Type: 3-way (normally open, normally closed or directional control); Pressure Range: 50-2000 PSI; Orifice Diameter: ¼"; Fluid Connections: to AND10050 for ¼" or ⅜" tube.

V50 SPECIFICATIONS: Type: 2-way (normally open or normally closed); Pressure Range: 50-3000 PSI; Orifice Diameter: ⅛" to ⅜"; Fluid Connections: to AND10050 for ¼", ⅜" or ½" tube.

Both valves are furnished with AN3102 Type Connectors.

Write for detailed specifications.

Skinner ELECTRIC VALVE DIV.
THE SKINNER CHUCK COMPANY
104 Edgewood Ave., New Britain, Conn.

These recently released photographs show two aircraft built for the military by Consolidated Vultee Aircraft Corporation. *Left* is the Air Force F-102, an all-weather supersonic interceptor of delta-wing configuration. *Right* is the Navy R3Y Tradewind. Both ships are shown during their take-off runs, the F-102 from Edwards AFB, Calif., and the R3Y from San Diego Bay. Further details concerning these two aircraft will be found in the Convair item on this page.

cessories, Inc. R. J. Levine, formerly AVIEN'S Director of Engineering, was appointed Vice-President and a Director of the Valhalla company. Other officers are: Mr. Weiss, Vice-President, and Hawley H. Myers, Secretary-Treasurer.

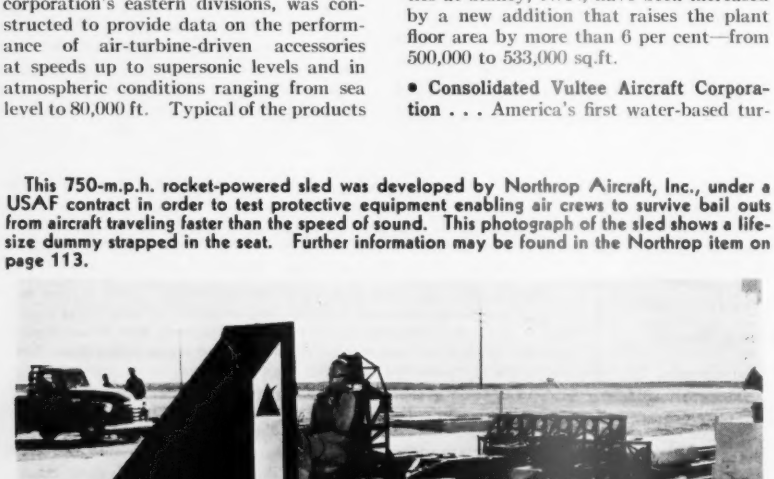
• **Beech Aircraft Corporation . . .** The one-thousandth Beechcraft Model D18S to be manufactured by Beech was delivered early last February. The D18S is a twin-engined executive transport.

• **Bell Aircraft Corporation . . .** Two standardized steel buildings, each with 20,000 sq.ft. of floor area, have been erected at Bell's helicopter plant in Hurst, Tex. Connecting these twin buildings is a 12,000-sq.ft. structure that is being used for pilot offices and servicing. These buildings, mass produced by Luria Engineering Company, represent a 25 per cent increase in the 200,000-sq.ft. Hurst plant.

• **Bendix Aviation Corporation . . .** According to a recent announcement, the nation's most extensive research facility for exclusive testing of component equipment for jet aircraft and missiles has been installed on a 102-acre site at the corporation's Eclipse-Pioneer Division. This new facility, which is to serve several of the corporation's eastern divisions, was constructed to provide data on the performance of air-turbine-driven accessories at speeds up to supersonic levels and in atmospheric conditions ranging from sea level to 80,000 ft. Typical of the products that the facility's engineering development work will serve are afterburner fuel pumps, water-alcohol pumps, turbine-driven alternators, bleed and burn turbine-driven accessories, cabin supercharger equipment, aircraft cooling equipment, pneumatic starters, and various other types of turbine-driven auxiliary equipment. . . . The Bendix Radio Division is marketing the Bendix SCL-3 Selective Calling System. This instrument comprises two basic units: the transmitting unit that is used at the ground station to modulate the transmitter and the receiving unit that is fed from the output of an air-borne receiver. The function of the system is to relieve the pilot or copilot in overwater flights of the necessity of wearing headphones constantly and yet permit the ground station to attract his attention by means of a flashing indicator light when a communication is required. The indicator light is designed to flash at the rate of approximately 120 times per min. . . . Effective February 15, the name of the corporation's Scintilla Magneto Division was changed to Scintilla Division. . . . The Scintilla Division's manufacturing facilities at Sidney, N.Y., have been increased by a new addition that raises the plant floor area by more than 6 per cent—from 500,000 to 533,000 sq.ft.

• **Consolidated Vultee Aircraft Corporation . . .** America's first water-based turboprop transport, the R3Y Tradewind, successfully completed its initial test flight on February 25. This 80-ton seaplane, built for the Navy by Convair's San Diego Division, was designed for speeds exceeding 350 m.p.h. It has a wing span of 145 ft., a length of 142 ft., 6 in.; and a height of 51 ft., 5 in. to the tip of its tail when the craft is beached on its cradle. The Tradewind is powered by four Allison T-40 turboprop engines, driving contrarotating Aeroproducts reversible-pitch propellers. Among the firsts claimed for the R3Y are: the first seaplane to be equipped with high-altitude pressurization and air-conditioning systems and the first water-based transport to be fitted with rearward-facing passenger seats. A built-in multicell compartmentation below the cabin deck level provides watertight integrity and leaves the deck free of bulkheads. The deck can support a weight of 300 lbs. per sq.ft., or a total of 48,000 lbs. The plane has a length-beam ratio of 10-to-1. The Tradewind will be operated by the Navy's Fleet Logistics Air Wings, Pacific Fleet, out of Alameda, Calif. . . . The new supersonic all-weather interceptor, the F-102, built for the Air Force by Convair, has a delta-wing configuration that closely resembles the earlier XF-92. The initial prototype of the F-102 was completed last October 5, was moved to Edwards AFB, Calif., for testing, and was damaged on November 2 in an emergency landing. A second prototype has been undergoing tests at Edwards since the middle of last December. . . . A manual on Engineering Cost Control has been undergoing continual expansion and revision over the past 8 years and has now grown into a 700-page work in three volumes. This manual is divided into two sections. The first section is on Methods Analyses and contains a comparison of the various methods of aircraft construction. The second section is made up of a series of subsections on 19 different items, as machining, castings, forgings, sheet metal, fastenings, etc., and tells the most economical way of manufacturing within that subsection. This manual will continue to grow as new methods are found and new ideas are developed. . . . On March 1, the Boards of Directors of Convair and General Dynamics Corporation voted in favor of a merger of Convair into General Dynamics. This action was subject to the approval on April 29 of the shareholders of both companies. No changes are contemplated in the management or among the officers of either cor-

This 750-m.p.h. rocket-powered sled was developed by Northrop Aircraft, Inc., under a USAF contract in order to test protective equipment enabling air crews to survive bail outs from aircraft traveling faster than the speed of sound. This photograph of the sled shows a life-size dummy strapped in the seat. Further information may be found in the Northrop item on page 113.



poration. Convair is to retain its name, individual identity, and organizational structure in every respect, except that it is to operate within the General Dynamics group. (This group includes Canadair Limited, which was acquired in 1947 by General Dynamics.) At the time that the proposed merger was made public, it was announced that Convair President Joseph T. McNarney was slated to become a Senior Vice-President of General Dynamics; he remains as Convair's head.

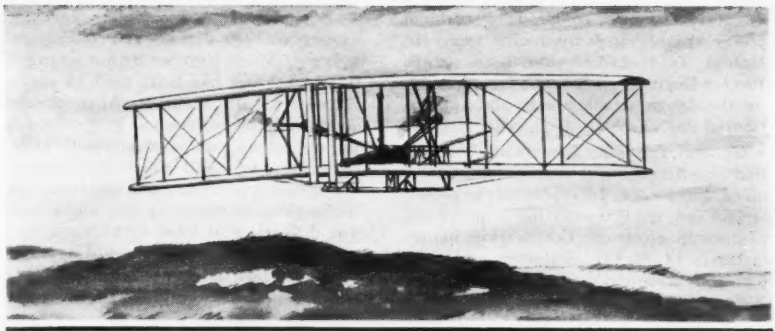
• **Decker Aviation Corporation . . .** A research program into the manufacture of instruments which is based upon a new and still classified transducer element has been announced by Decker. It was stated that the initial efforts of the company "will be directed toward effecting vast simplification in instrumentation used by the aircraft industry, as well as introducing new instrumentation for highly specialized problems." This work is being conducted in a newly acquired 8,000-sq.ft. laboratory adjacent to the company's Philadelphia facilities.

• **Douglas Aircraft Company, Inc. . . .** The A3D twin-jet Navy bomber, now in early production at Douglas' El Segundo Division, has been given the name Skywarrior. Powered with Pratt & Whitney J-57 turbojet engines, the A3D Skywarrior was designed to perform in the 600-m.p.h. class and above 40,000 ft. It carries a crew of three—pilot, bombardier, and gunner-navigator. A Douglas official stated that the bomber was designed to operate from Navy carriers presently in use, as well as from supercarriers of the Forrestal class now under construction. The wings and tail of the A3D fold to facilitate handling and storage aboard carriers. This ship made its first flight on October 28, 1952; the first flight of a production model was on September 16, 1953. USAF versions of the A3D bomber, the B-66 and RB-66, are entering production at the company's Long Beach Division.

• **Elastic Stop Nut Corporation of America . . .** Bulletin SR5, put out by ESNA's AGA Division, describes the Model SF Agastat hermetically sealed time-delay relay. This 1.2-lb. Model SF Agastat measures $2^1/_8$ by $2^5/_{32}$ by $3^7/_8$ in. The length of the time delay is externally adjustable over a range from 0.030 to 120 sec.

• **Fairchild Engine Division, Fairchild Engine and Airplane Corporation . . .** A West Coast office, with Thomas M. Sullivan, MIAS, as West Coast Representative, has been opened and is located in the Professional Building, 7046 Hollywood Blvd., Hollywood 28, Calif. This new office enables the Engine Division to maintain closer liaison with air-frame and missile manufacturers, as well as USAF and USN bases located in the western part of the United States.

• **General Electric Company . . .** A gas-turbine engine for helicopters, designated the XT-58, is being developed by G-E for the Navy's BuAer. The new engine will compare in size with a conventional automobile power plant, but it will be six to eight times as powerful. While the XT-58 is being designed primarily for helicopters, certain modifications would permit its



$$F = C\frac{\rho}{2}SV^2$$

IN 1903, when the Wright Brothers were constructing the first successful powered airplane, there was data available on the forces on flat plates held at various angles in the wind. The problem of maintaining equilibrium presented the greatest difficulty of solution. The Wright Brothers had to depend on ingenuity, perseverance, courage and a home-made wind tunnel for solutions to their problems.

TODAY, IN 1954, aircraft development and production depend on the scientific skill of highly trained Engineers. During the past 50 years these Engineers have evolved countless formulae, such as the *Force-In-Pounds* equation above, to help provide simple solutions to aeronautical problems which once seemed insurmountable.

IN THE YEARS AHEAD, sub-sonic, trans-sonic and supersonic problems will give way to hyper-sonic inquiries as new and greater opportunities challenge Aeronautical Engineers. If progress is to be made, new ideas are needed. New formulae must conquer problems of stress, space, loads and high speeds.

TO MEET THIS CHALLENGE, CONVAIR needs more Engineers with ingenuity. To get the job done will require "Engineering to the Nth Power." CONVAIR has the experience, record of past performance, leadership, determination and facilities to do the job.

OPPORTUNITIES ARE UNLIMITED at CONVAIR for high caliber creative Engineers. If you have confidence in your ability to help create tomorrow's aircraft, inquire now about these excellent opportunities . . . permanent positions . . . ideal working conditions and living environment in FORT WORTH, TEXAS.

CONVAIR

Send Resume to M. L. Taylor
Engineering Personnel Dept. 6-DD
CONSOLIDATED VULTEE
AIRCRAFT CORPORATION
FORT WORTH, TEXAS

adaptation as a turboprop or turbojet power plant for fixed-wing aircraft. Harold T. Hokanson has been named Project Engineer and as such is responsible for the design, development, and applications of the XT-58.

• **General Precision Equipment Corporation . . .** According to a recent announcement, Librascope, Incorporated, a subsidiary of General Precision, has acquired the Minnesota Electronic Corporation, manufacturers of digital computers and components. It is understood that Minnesota Electronics will continue to operate with the same management and personnel.

• **Kollsman Instrument Corporation . . .** The existence of the Kollsman Supersonic Machmeter, an instrument that indicates Mach Number, was recently announced. This Supersonic Machmeter, developed as early as 1949, directly and continuously indicates Mach Number within a range of 0.7 to 3.0 and has been used in several record-breaking flights. A mechanical computer, this instrument is operated by the impact and static pressures furnished by a pitot tube. A differential pressure diaphragm and an aneroid diaphragm are the sensing elements of the mechanism. The deflections of these diaphragms operate on a lever system, the resulting movement of which is then transmitted by a gear train to the pointer, giving thereby a continuous visual indication of Mach Number. The Kollsman Subsonic Machmeter with a range from 0.3 to 1.0 and the Transonic Machmeter with a range from 0.5 to 1.5 have been used for some years, both operationally and as test-flight instruments.

• **Lear, Incorporated . . .** The LearCal Division is now manufacturing a new type rigid Automatic Direction Finder loop corrector device that, according to the company, is adjustable to provide correction in 5, 10, 15, and 20° increments. . . . Dr. Charles J. Breitwieser, Lear's Director of Engineering and Manager of the General Development and Engineering Division, has been elected a Vice-President of the corporation. . . . Chester D. Seftenberg, a former Deputy Assistant Secretary of the Air Force, has been named Treasurer. Mr. Seftenberg has his headquarters at Lear's Grand Rapids Division.

• **Lockheed Aircraft Corporation . . .** Research engineers at Lockheed recently unveiled an electronic instrument capable of reducing the scrambled sounds received during a guided-missile flight test into separate scientific messages. Described as an automatic data reduction machine, this new device enables researchers to plot and analyze a missile's flight history within a 2- or 3-day period. (This job formerly took weeks to accomplish.) This instrument reportedly unscrambles as many as 30,000 readings per min. telemetered from the missile in flight and classifies them accurately. The data include measurements of speed, heat, stresses and forces, steering signals, and engine performance. To accomplish this, the telemetered information is captured by a multichannel recording tape that in turn feeds the recorded information into an electrical pulse converter. This converter controls a standard accounting-type card-punching machine. Once the data are in punched-card form, they can be computed electronically, and the cards can be arranged and fed into an automatic plotting machine, developed by Lockheed. The data are finally recorded on ordinary graph paper as curves for study and appraisal by Lockheed engineers. This new device is believed to be the first ever to convert this class of radioed signals directly into numbers. . . . According to a recent report, a contract has been signed by Lockheed and Kawasaki Aircraft Company, of Japan, whereby the Japanese firm acquires manufacturing rights on the Lockheed F-94 Starfire and T-33 jet trainer. The contract is said to include all the technical help needed from Lockheed and advice from the American company on the repair work currently being accomplished on American military jet aircraft at Kawasaki's plant at Gifu, near Nagoya. The agreement is further said to include jet-engine manufacture and repair by Kawasaki under the terms of a contract between Lockheed and General Motors Corporation's Allison Division. . . . Three major accomplishments with the turbo-compound Super Constellations were recently announced. The first of these was in the rate of production, with Eastern's latest order for 16 Super Constellations being filled one a week in exactly 16 weeks. The second accomplishment was Eastern's placing of its new Super Constellations into service in an average of 4 days from the date of delivery. The third one was the time on the New York-Miami

run; the schedule between these two cities calls for 3 hours, 45 min., but the run has been made as fast as 2 hours, 29½ min. Lockheed reported that the one-a-week delivery record was attained while Super Constellations were rolling to Air France, Pakistan International, Trans-Canada Air Lines, KLM, the USAF, and the USN. Eastern now operates a fleet of 18 Constellations and 29 Super Constellations.

• **McDonnell Aircraft Corporation . . .** A new building of 485,000 gross sq.ft., now being built by the U.S. Navy at Lambert Field in St. Louis, is being leased to McDonnell and will house receiving, fabrication, and machine-shop operations. Scheduled for completion in October of this year, it will be partially occupied this coming June.

• **Minneapolis-Honeywell Regulator Company . . .** Stephen F. Keating has been appointed to the newly created post of Vice-President of the corporation's Aeronautical Division. Mr. Keating was formerly Assistant General Manager of the Aeronautical Division. . . . C. L. Peterson was recently appointed Divisional Vice-President of the company's Brown Instruments Division.

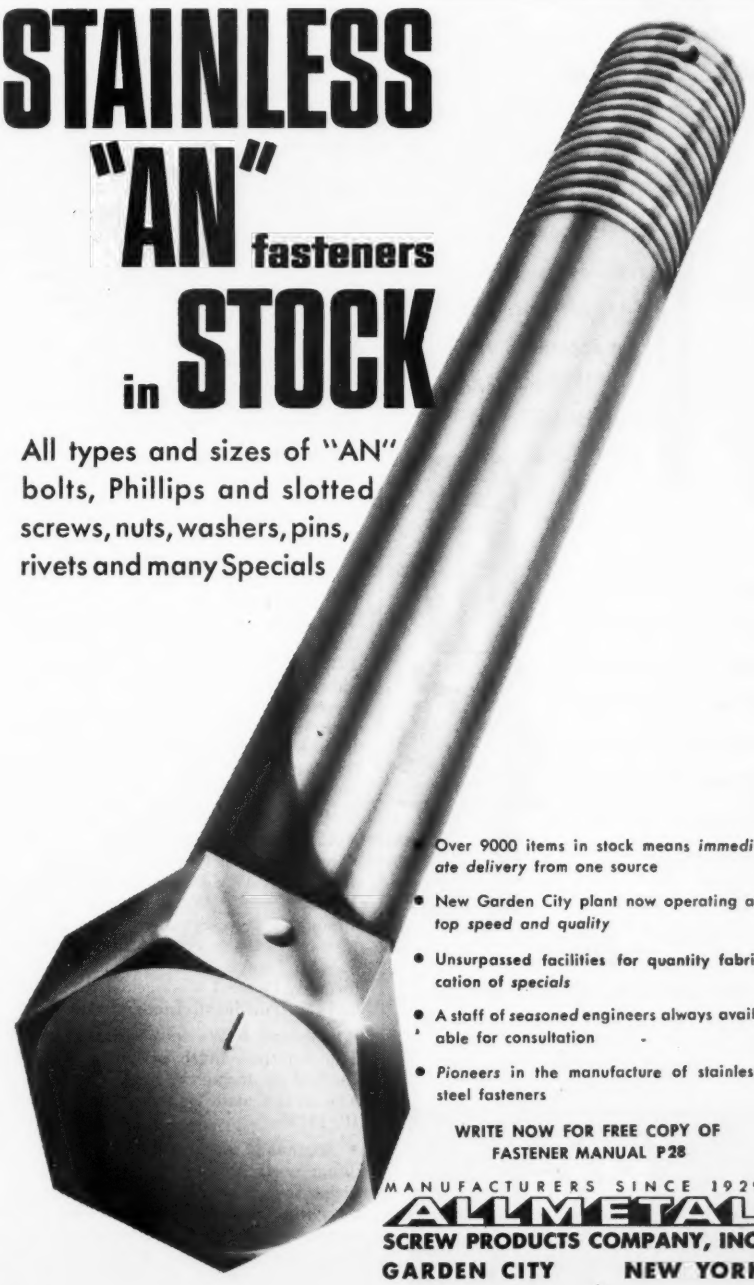
• **Northrop Aircraft, Inc. . . .** Experiments to provide a reliable way of testing advanced survival methods of protective equipment for crews of supersonic military airplanes are being conducted on a 3,500-ft. railroad track at Holloman Air Development Center, N.M., by Air Research and Development Command scientists. The equipment being used in these experiments was designed and built by Northrop under ARDC's Wright Air Development Center Aero Medical Laboratory specifications and consists of two sleds—a test vehicle and a propulsion vehicle. The propulsion vehicle pushes the test vehicle until it reaches the required speed and then is retarded while the test vehicle coasts free at high speed during the brief testing period. This equipment, by virtue of twelve 4,500-lb.-thrust rockets, can reach speeds up to 750 m.p.h., which at Holloman's altitude (4,092 ft. above sea level) simulates a bail out from an open seat at 40,000 ft. at a speed of 1,800 m.p.h. The test vehicle was designed to withstand forces up to 100 *g*'s with a 50 per cent safety factor. Instrumentation records the reactions of the subject and survival equipment during each run. Dummies are being used in the initial tests, with USAF volunteers following in later tests. These experiments are being directed by Lt. Col. John P. Stapp, USAF, winner of The John Jeffries Award for 1952 presented to him by the Institute of the Aeronautical Sciences for his human-deceleration studies carried out at Edwards AFB, Calif., on another Northrop-built rocket-powered sled. . . . A twin-jet Scorpion has been converted into a "flying test bed" and is being used by Northrop to test new turbojet engines for the Air Force. This ship is designated the YF-89E. The YJ-71-A-3 jet engine, manufactured by the Allison Division of General Motors Corporation, is being tested in the YF-89E to determine that engine's flight characteristics and general performance under varying flight conditions.

• **Pan American World Airways, Inc. . . .** A Cargo Reservations Department has been established in order to handle air freight on the same reservations procedure used in booking passengers. Under the new procedure, cargo reservations are accepted at any Pan American sales office in the country on all regular PAA passenger and scheduled cargo flights. For the present, reservations are accepted for shipments weighing up to 500 kilos (1,100 lbs.) for all-cargo flights and up to 50 kilos (110 lbs.) for passenger flights. Reservations on specific flights for heavier shipments must be confirmed. . . . The company's $800,000 flight simulator for the Boeing Stratocruiser was transported last March to San Francisco for further use. This simulator, made by Curtiss-Wright Corporation, had spent 5½ years at New York's LaGuardia Field and during that time was used to train 2,080 airmen, both commercial and military. . . . A contract to operate some of the installations at the USAF Missile Test Center, Cocoa, Fla., has been awarded to Pan American. Radio Corporation of America has been named subcontractor for the electronics portion of the work.

• **The Parker Appliance Company . . .** The company's line of reusable-type Hoze-lok fittings has been expanded to include 13 additional sizes of the industrial hose couplings. These additions, which conform to SAE Hose Fitting Standards

STAINLESS "AN" fasteners in STOCK

All types and sizes of "AN" bolts, Phillips and slotted screws, nuts, washers, pins, rivets and many Specials

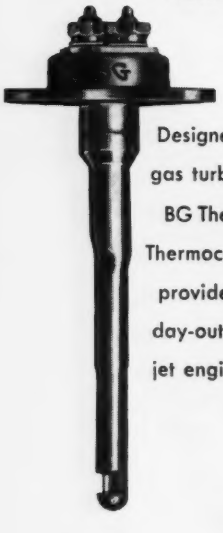


- Over 9000 items in stock means *immediate delivery* from one source
- New Garden City plant now operating at *top speed and quality*
- Unsurpassed facilities for quantity fabrication of *specials*
- A staff of *seasoned* engineers always available for consultation
- *Pioneers* in the manufacture of stainless steel fasteners

WRITE NOW FOR FREE COPY OF FASTENER MANUAL P28

MANUFACTURERS SINCE 1929
ALLMETAL
SCREW PRODUCTS COMPANY, INC.
GARDEN CITY NEW YORK

BG
IS A MUST
FOR AVIATION
TOP
PERFORMANCE



Designed especially for gas turbine application, BG Thermocouples and Thermocouple Harnesses provide steady, day-in-day-out performance on jet engines in operation the world over.

Precision-tooled and manufactured to fit *all* types of aircraft engines, BG Spark Plugs meet the most diversified operating requirements and the highest mechanical specifications.

—BG—

the name that's first with aircraft engineering and maintenance personnel.

★

For information concerning these and other BG products, write to

THE
BG
CORPORATION
136 WEST 52nd STREET • NEW YORK 19, N.Y.

and applicable specifications of JIC Hydraulic Standards, are said to eliminate the need for reducers in many combination-size connections when diameter reduction from hose to tubing is desired.

• **Piasecki Helicopter Corporation . . .** The former Autocar factory at Ardmore, Pa., 12 miles from Piasecki's main plant in Morton, Pa., has been leased by Piasecki and will be used primarily for manufacturing helicopter components. The leasing of this Ardmore facility, which consists of two buildings with some 240,000 sq.ft. of area, was needed to provide for the company's announced policy of reducing the amount of subcontracted work on aircraft parts. Occupancy of this newly leased area was scheduled for the first of this month; additional time, however, is required to equip the plant before the actual manufacturing begins on a large scale. The company stated that mainly manufacturing personnel are being used in the new plant. Engineering, technical, and office employees remain at Morton.

• **Reaction Motors, Inc. . . .** An office was recently established in Washington, D.C., in order to provide more effective liaison with the company's customers, with a view toward expediting and facilitating existing and future programs, including the contract administration and negotiations relating thereto. William M. Davidson has been named Reaction Motors' Washington Representative and is located at 1883 Jefferson Place, N.W., in the offices of Jones and Gillies, Inc., Aviation Consultants.

• **Republic Aviation Corporation . . .** The company recently announced the first deliveries of the new high-speed photo-reconnaissance fighter, the RF-84F Thunderflash. The Thunderflash, which carries four 0.50-cal. machine guns, has its air-intake ducts located in the wing roots to permit installation of a variety of cameras in the nose. The Thunderflash is used by the Air Force in "Project FICON" in which an RB-36 becomes an aircraft carrier and by means of a trapeze mechanism can launch and recover the photoplane in mid-air. (The Thunderflash has a 2,000-mile range, and the bomber has a 10,000-mile range.) The new photofighter is powered by a single 7,200-lb.-thrust J-65 Sapphire turbojet engine.

• **A. V. Roe Canada Limited . . .** F. T. Smye was recently named Vice-President and General Manager of the Aircraft Division, while W. R. McLachlan was appointed Vice-President and General Manager of the Gas Turbine Division. Messrs. Smye and McLachlan were formerly General Manager of the Aircraft and Gas Turbine divisions, respectively.

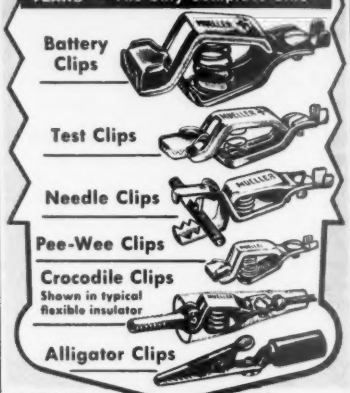
• **Seaboard & Western Airlines, Inc. . . .** The five-thousandth ocean crossing was chalked up during the month of January. The air line made its initial flight on May 10, 1947.

• **Simmonds Aerocessories, Inc. . . .** A design portfolio containing full-scale drawings and data sheets on Simmonds heavy-duty structural latches is now being offered to aeronautical and industrial engineers This new publication gives information on the complete line of Simmonds latches,

A THOUSAND USES FOR

Mueller
BATTERY &
TEST CLIPS

FOR 45 YEARS
• World's Largest Producer
• The Only Clip Specialists
• The Only Complete Line



A CLIP FOR EVERY PURPOSE!
Ask for our NEW Catalog B573
Flexible insulators to fit each size.
Made in 10 sizes from 5 to 300 Amps. Steel or solid copper.

Mueller Electric Co
1573B EAST 31 STREET • CLEVELAND 14, OHIO

PICKERING
solenoids

for DC Circuits

Pickering engineering service is available for special applications where Pickering standard Solenoids do not apply.

PICKERING & CO., Inc.

Manufacturers of world-famous electro-magnetic phonograph cartridges and audio equipment.

Oceanside, L. I., New York

For details and literature address Department A

designed for aircraft installations and specialized industrial applications. Copies of this portfolio may be obtained by writing to Simmonds.

• **Sperry Gyroscope Company, Division of The Sperry Corporation . . .** Recently opened at MacArthur Field, L.I., is a new aeronautical service center. This new center provides "complete and rapid" service on flight and engine instruments and automatic pilots for a large number of corporate aircraft and utility planes now equipped with Sperry automatic controls or other flying aids.

• **Thompson Products, Inc. . . .** A pictorial history of aviation has been put out by Thompson. The album includes 191 paintings by Charles H. Hubbell, a professional artist who is known around the world as one of aviation's best pictorial historians. The "Panorama of Flight" depicted in the publication begins with Henson's "Ariel" (1842) and ends with the Douglas DC-7.

• **Vickers, Inc. . . .** The Vickers Flow Sensitive Pressure Regulator has been announced by the company and is said to respond to the flow of oil entering it in such a way that the relief-valve setting decreases as the inlet flow decreases. Because of this feature, the company says that a fixed-displacement hydraulic pump will not stall when the input torque is reduced below that value required to meet the setting of an ordinary fixed-setting pressure-relief valve. A new brochure, *A-5226*, describing the new Vickers valve may be secured by writing to Vicker's Detroit office.

IAS Sections

Baltimore Section

Richard W. Sanford, *Secretary*

The forty-eighth meeting of the Baltimore Section was held in Remsen Hall at The Johns Hopkins University on Thursday, February 25, at 8:30 p.m. The meeting was attended by approximately 75 members and guests.

The major item of business consisted of the presentation of a talk on "Structural Adhesive Bonding in Production Aircraft," by James L. Burridge of The Glenn L. Martin Company. Mr. Burridge's discussion was devoted primarily to the use of honeycomb techniques in The Glenn L. Martin Company's B-61 Matador.

It was pointed out that aircraft structural engineers have long been intrigued by the possibility of eliminating the multitudinous assembly operations required for the manufacture of air-frame structures. One approach has resulted in assembly by simple application of temperature and pressure. Adhesives are used to join metal skins to low-density cores, thus forming sandwich-type structures that completely eliminate conventional rivets and bolts.

ANOTHER EXAMPLE OF Waterman PIONEERING...

The S-12-B RAKSCOPE is a rack mounted, JANized (Gov't Model No. OS-11) version of the famous WATERMAN S-11-A POCKETSCOPE, with the addition of a triggered sweep and a special calibrating circuit for rapid frequency comparisons. The entire oscilloscope is built to occupy but seven inches when mounted in a standard relay rack. The vertical and horizontal amplifiers are identical, having sensitivities of 0.05 Volt rms/inch and frequency responses which are flat within —2 db from DC to 200 KC. These features permit observation of low frequency phenomena without undesirable trace bounce. The sweep rate is continuously variable from 5 cycles to 50 KC in either the triggered or repetitive mode with synchronization polarity optional. The return trace is blanked. Because provisions are made for applying input signals from the rear, as well as the front, the S-12-B is the ideal combination, systems monitor and trouble-shooting oscilloscope. Investigate the multiple applications of this instrument as an integral part of your "rack mounted" projects.

WATERMAN PRODUCTS CO., INC.
PHILADELPHIA 25, PA.
CABLE ADDRESS: POKETSCOPE

WATERMAN PRODUCTS INCLUDE

S-4-C SAR PULSESCOPE®
S-5-A LAB PULSESCOPE
S-6-A BROADBAND PULSESCOPE
S-11-A INDUSTRIAL POCKETSCOPE®
S-12-B JANized RAKSCOPE®
S-14-A HIGH GAIN POCKETSCOPE
S-14-B WIDE BAND POCKETSCOPE
S-15-A TWIN TUBE POCKETSCOPE
RAYONIC® Cathode Ray Tubes
and Other Associated Equipment

The electronic computer gulps algebraic equations and releases typed solutions, at the rate of 10,000 per minute. Men with vision created this machine that almost *thinks*, men who were dissatisfied with old fashioned methods.

Dissatisfaction—

AMERICA'S GREATEST ASSET

Computing machines have created one of the fabulous chapters in the history of American industry. A few enterprising men in each generation have been unwilling to tolerate mediocre tools and methods. They are the physicists, engineers and designers who today are meeting the requirements of our changing world. At Meletron we are testing new materials and creating new techniques to meet constantly higher standards. Dissatisfaction with what has been done, plus the determination to improve, is one of America's greatest assets. This attitude is a guiding policy at Meletron.

MELETRON® CORPORATION

950 NORTH HIGHLAND AVENUE, LOS ANGELES 38, CALIFORNIA

J. M. WALTHEW CO., Boeing Field, Seattle. THOMSON ENGINEERING SERVICE, 708 Hemphill St., Fort Worth and 732 So. Broadway, Wichita. ROUSSEAU CONTROLS Ltd., 2215 Beaconsfield Ave., Montreal 28, Canada. W. M. HICKS & J. A. KEENETH, 29-27 Forty-first Avenue, Long Island City, New York. JOSEPH C. SORAGHAN & ASSOCIATES, 1612 Eye St., Northwest, Washington 6, D.C.

Major weight-savings are realized in addition to reduced manufacturing costs.

Investigation of lightweight core materials and bonding techniques was started at the Martin Company in 1939. As a result of this investigation, aluminum foil formed into honeycomb cells has been selected as being the most versatile core material. The core material and skin surfaces are joined by a bonding agent that is sold under the trade name "FM-47" by Bloomingdale Rubber Company. Foil thickness and cell size may be varied to provide a range of strength properties. Also, it is possible to densify the core by collapsing cells locally or to insert a flat sheet between corrugated layers thus splitting each cell longitudinally to provide improved compressional stability. FM-47 is available both in liquid form and as a prepared film.

To achieve a bonded joint between one aluminum sheet and another or between a sheet and honeycomb core, four steps are required. The sheet must be cleaned, coated with adhesive, force-dried to remove volatiles, and finally cured under temperature and pressure. This process will provide an adhesive joint between core and face material having sufficient strength to stabilize aluminum faces against buckling up to the compression yield. Metal-to-metal joints will typically develop over 4,000 lbs. per sq.in. in the adhesive when a standard $^1/_2$-in. lap joint specimen of 0.064 sheet is tested. Joint strength of FM-47 has not been found to be a function of glue-line thickness over a practical manufacturing range of 0.003 to 0.030 in. Characteristics of the adhesive with regard to creep, fatigue, and temperature effects have been investigated sufficiently to justify the statement that few limitations on its use from these standpoints are apparent. Humidity effects are not significant in reducing the adhesive's strength.

Experience on a number of Martin missiles and airplanes has shown that effective utilization of adhesive bonded structures requires the application of sustained effort and the accumulation of know-how by five distinct groups in successive waves of activity as follows:

(1) *Laboratory.*—Basic investigation of material and adhesive characteristics is provided by this group.

(2) *Design Engineering.*—Lessons learned by Martin engineers are as follows:

(a) A successful adhesive bonded structure must be designed for adhesive at the outset. It must not be a conversion of a riveted design.

(b) The designer must consider in greater detail the tooling problems associated with the structure.

(c) Full advantage should be taken of the fact that once an assembly is prepared for a bonding cycle, it costs little to complete the major splices at the same time.

(d) Standard sheet stock can be used to make laminated, tapered, or sculptured skins. This is accomplished by appropriate lay-up arrangement.

(3) *Tool Design.*—Tooling must be started during the early part of the engineering phase. The following important tooling lessons have been learned:

(a) Tools must be designed to provide application of the required temperature and pressure *at the glue lines.*

(b) The part, not the entire tool, should be heated to effect a short heat-up time and good temperature control.

(c) For high rates of production and small, easily expanded facilities, electric bag-diaphragm bonding should be investigated.

(d) Mild forming or rolling of laminated sheets can be accomplished after completion of the bonding process.

(4) *Manufacturing.*—A difficult transition from the drill and rivet system to the glue system has been accomplished. The most important watchword associated with the manufacturing process is *cleanliness,* and each individual contributes toward this objective—from management down to helper.

(5) *Quality Control.*—Effective quality control is accomplished by step-by-step process control in addition to verification checks by means of tension samples taken after assembly.

It was concluded that production adhesive bonding of flat and contoured primary structures, with all of its inherent advantages, is fully available to the industry today. However, continued coordination of laboratory, engineering, tooling, manufacturing, and quality-control effort is still required to build the confidence that must exist on the part of all concerned in the excellence of the end product.

At the conclusion of his talk, which was well illustrated with slides and examples, Mr. Burridge showed a moving picture film depicting significant stages associated with the manufacture and quality control of Matador surfaces utilizing adhesive bonded-construction techniques.

Chicago Section

Leland W. Sims, *Secretary*

On February 24, the Chicago Section met at the Illinois Institute of Technology in Chicago. Dinner was served at 6:30 p.m. to 26 members and guests in the Student Union Building. After dinner, the group proceeded to the auditorium of the Chemistry Building,

YOU NAME THE NEED . . .

we'll build the inverter!

Bendix Red Bank offers you the widest range of aircraft inverters found anywhere. And because each Red Bank inverter is engineered and built as a complete, unified mechanism, it provides maximum operating efficiency on the job it is designed to do.

Over and above current production models, Bendix Red Bank experts develop and manufacture a large number of custom-built inverters for highly specialized applications. For example, in the missile field alone, a wide variety of Red Bank inverters are today giving peak performance under conditions previously thought too severe for dependable operation.

Now under construction are still other specialized inverters designed to meet even more severe environmental conditions.

Out of this unique background has emerged the experience, manpower and facilities that equip Bendix Red Bank to build inverters to fit any specialized needs.

You tell us your need, and we'll build an inverter to handle it. Write today for further information.

Manufacturers of Special-Purpose Electron Tubes, Inverters, Dynamotors and Fractional HP D.C. Motors.

Bendix Red Bank

EATONTOWN, N. J.

DIVISION OF Bendix AVIATION CORPORATION

THE NAME MILLIONS TRUST

West Coast Sales and Service: 117 E. Providencia, Burbank, Calif.
Export Sales: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.
Canadian Distributor: Aviation Electric Ltd., P. O. Box 6102, Montreal, P. Q.

IAS Preprints

Preprints of 22nd Annual Meeting Papers Currently Available

		Member Price	Nonmember Price
465	ANDB's Program for the Development of an Air Traffic Control System—D. K. Martin.	$0.65	$1.00
464	The Role to Be Played by Training Devices in the Training of Aviation Personnel—Edmund O. Carmody.	0.50	0.85
462	The Story of Shimmy—William J. Moreland.	0.65	1.00
461	Airplane Design in Relation to Safety—R. W. Rummel.	0.50	0.85
460	Management's Economic Interest in Safety—Carl M. Christenson.	0.35	0.75
458	Military Personnel Training Requirements—Brig. Gen. G. F. Schlatter.	0.35	0.75
456	Aerodynamics of Blasts: Diffraction of Blast Around Finite Corners—H. F. Ludloff and M. B. Friedman.	0.35	0.75
454	Current Methods and Future Needs in Selecting Aviation Personnel—Jack W. Dunlap.	0.35	0.75
453	On the Wake and Drag of Bluff Bodies—Anatol Roshko.	0.50	0.85
452	Experimental Investigation of Turbulent Boundary Layers in Hypersonic Flow—R. Kenneth Lobb, Eva M. Winkler, and Jerome Persh.	0.50	0.85
449	Some Applications of Generalized Harmonic Analysis to Gust Loads on Airplanes—Harry Press and John C. Houbolt.	0.50	0.85
448	The Estimation of Normal-Force, Drag, and Pitching-Moment Coefficients for Blunt-Based Bodies of Revolution at Large Angles of Attack—Howard R. Kelly.	0.50	0.85
447	Economic Considerations of the Transport Helicopter—James B. Edwards.	0.35	0.75
446	Some Considerations on the Air Forces on a Wing Oscillating Between Two Walls for Subsonic Compressible Flow—Donald S. Woolston and Harry L. Runyan.	0.50	0.85
445	Application of Sailplane Performance Analysis to Airplanes—August Raspet.	0.35	0.75
444	Personnel Training Required to Produce Large Quantities of High-Performance Aircraft—Leverett P. Wenk.	0.50	0.85
443	Analysis of Flutter in Compressible Flow of a Panel on Many Supports—John M. Hedgepeth, Bernard Budiansky, and Robert W. Leonard.	0.50	0.85
442	A Theoretical Investigation of the Oscillating Control Surface Frequency Response Technique of Flight Flutter Testing—R. A. Pepping.	0.50	0.85
441	The Separation of a Supersonic Turbulent Boundary Layer—Seymour M. Bogdonoff and C. Edward Kepler.	0.35	0.75
440	A Method for Estimating Wing Weights—Abraham Hyatt.	0.50	0.85
439	Three-Dimensional Laminar Boundary Layer with Small Crossflow—Artur Mager.	0.50	0.85
438	Transition-Point Fluctuations in Supersonic Flow—John C. Evvard, Maurice Tucker, and Warren C. Burgess, Jr.	0.50	0.85
437	Effect of Leading Edge Separation on the Lift of a Delta Wing—C. E. Brown and W. H. Michael, Jr.	0.35	0.75
435	An Approach to the Buffeting of Aircraft Structures by Jets—John W. Miles.	0.50	0.85
434	Pseudo-Transonic Similitude and First-Order Wave Structure—Wallace D. Hayes.	0.50	0.85
433	Generalized Aerodynamic Forces on the Delta Wing with Supersonic Leading Edges—J. Walsh, G. Zartarian, and H. M. Voss.	0.50	0.85
432	Secondary Flows in Cascades of Twisted Blades—Fredric F. Ehrich.	0.50	0.85
431	Prediction of Ultimate Strength of Skin-Stringer Panels from Load-Shortening Curves—Norris F. Dow and Roger A. Anderson.	0.50	0.85
430	Determination of Loads in the Presence of Thermal Stresses—Samuel Levy.	0.35	0.75
429	On Inelastic Thermal Stresses in Flight Structures—Alfred M. Freudenthal.	0.35	0.75
428	Strength Under Combined Tension and Bending in the Plastic Range—J. M. Frankland and R. E. Roach.	0.50	0.85
427	On the Concept of Stability of Inelastic Systems—D. C. Drucker and E. T. Onat.	0.35	0.75

Preprints should be ordered by number from:

Preprint Department, Institute of the Aeronautical Sciences

2 East 64th Street, New York 21, N.Y.

Ketay

presents

... *meticulously tailored*

MAGNETIC AMPLIFIER SERVO SYSTEMS

Typical characteristics of some magnetic amplifier and two-phase servo motor combinations available from Ketay.

SPECIFY MAGNETIC AMPLIFIER (type)	FREQUENCY (cps)	LINE VOLTAGE (volts)	LENGTH (inches)	WIDTH (inches)	HEIGHT (inches)	SPECIFY SERVO MOTOR (type)	TORQUE AT STALL (oz. in.)	MOMENT OF INERTIA (oz. in. x sec^2 x 10^4)	ACCELERATION AT STALL (rad./sec^2)	NO LOAD SPEED (min. r.p.m.)	RATED VOLTAGE EXCITATION FIXED PHASE (volts) *	INPUT POWER PER PHASE AT STALL (watts)	DIAMETER (inches)	LENGTH (inches)
SMA6-102	60	115	4 1/2	3 3/4	3 7/8	K402530	2.5	49.5	50,500	3300	115	9.2	1 3/4	2
SMA6-102	60	115	4 1/2	3 3/4	3 7/8	K402380	1.45	42.8	35,000	3200	115	5.0	1 7/16	1 5/8
SMA4-102	400	115	4 1/8	3 5/16	4 3/16	K402550-1	2.35	49.5	47,500	4800	115	9.2	1 3/4	2
SMA4-102	400	115	4 1/8	3 5/16	4 3/16	K402550-2	2.35	49.5	47,500	4800	115	9.2	1 3/4	2
SMA4-102	400	115	4 1/8	3 5/16	4 3/16	K101600-6	1.45	42.8	35,000	4800	115	6.1	1 7/16	1 5/8
SMA4-102	400	115	4 1/8	3 5/16	4 3/16	K101660	1.45	42.8	35,000	4800	115	6.1	1 7/16	1 5/8

BUORD DESIGNATIONS FOR SERVO MOTORS
K101600-6 = MK 7 MOD 0 K101660 = MK 7 MOD 1
K402550-2 = MK 8 MOD 1 K402550-1 = MK 8 MOD 0

* The control phase of all Servo Motors should be connected for 57.5 volt operation.

On the other side of this page are listed some of the synchros for which the combinations were specially designed.

Ketay supplies complete systems including gear trains and stabilization for given kinematic requirements.

Servo motor-tachometer generator combinations are also available.

Ketay welcomes the opportunity to design and fabricate amplifiers of both the conventional and miniaturized types to customer's specifications.

See Ketay's Exhibit at Airborne Electronics Conference
Dayton Biltmore Hotel, May 10-12

SYNCHROS • SERVO MOTORS
RESOLVERS • MAGNETIC AMPLIFIERS
AIRBORNE INSTRUMENTS
AUTOMATIC CONTROL SYSTEMS

Ketay

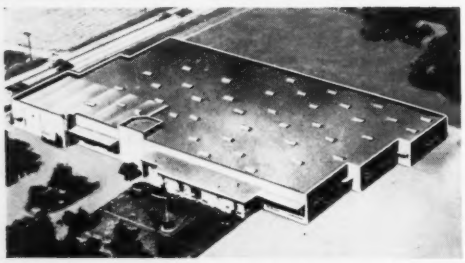
MANUFACTURING CORP.
Executive Offices
555 Broadway, New York 12, N. Y.

KETAY OFFERS A COMPLETE RANGE OF SIZES AND TYPES IN SYNCHROS • SERVO MOTORS RESOLVERS

1–SERVO MOTOR, Size 10 Frame, O.D. .937″
2–SYNCHRO, Size 10 Frame, O.D. .937″ (Transmitter, Receiver, Resolver, Differential Transmitter, Control Transformer)
3–SERVO MOTOR, Size 10 Frame, O.D. .937″
4–SYNCHRO, Size 11 Frame, O.D. 1.062″ (Transmitter, Resolver, Control Transformer)
5–SERVO MOTOR, Mk 14, Size 11 Frame, O.D. 1.062″
6–SYNCHRO, Size 15 Frame, O.D. 1.437″ (Transmitter, Receiver, Resolver, Differential Transmitter, Control Transformer)
7–SERVO MOTOR Mk 7, Size 15 Frame, O.D. 1.437″
8–SYNCHRO, Size 15 Frame, O.D. 1.437″ (Transmitter, Receiver, Resolver, Differential Transmitter, Control Transformer)
9–LINEAR TYPE CONTROL TRANSFORMER, O.D. 1.625″
10–SERVO MOTOR, Mk 8, Size 18 Frame, O.D. 1.75″
11–INDUCTION MOTOR, Size 20 Frame, O.D. 1.95″
12–SYNCHRO, Size 16 Frame, O.D. 1.537″ (Transmitter, Receiver, Control Transformer)
13–SYNCHRO, Size 18 Frame, O.D. 1.750″ (Transmitter, Receiver, Differential Transmitter, Control Transformer)
14–INDUCTION MOTOR, Size 18 Frame, O.D. 1.750″, 3 Phase, 2 Pole
15–SYNCHRO, Size 19 Frame, O.D. 1.90″ (Transmitter, Receiver, Control Transformer)
16–SYNCHRO, Type 1F, 1HCT, or 1HG Size 1 Frame, O.D. 2.250″ (Receiver, Transmitter, Control Transformer)
17–INDUCTION MOTOR, Size 1 Frame, O.D. 2.250″
18–SYNCHRO, Size 23 Frame, O.D. 2.250″ (Transmitter, Receiver, Resolver, Differential Transmitter, Control Transformer)
19–SERVO MOTOR, Size 23 Frame, O.D. 2.250″
20–SYNCHRO, Size 31 Frame, O.D. 3.10″ (Transmitter, Receiver, Differential Receiver, Differential Transmitter)

Typical characteristics of 116 units are available.

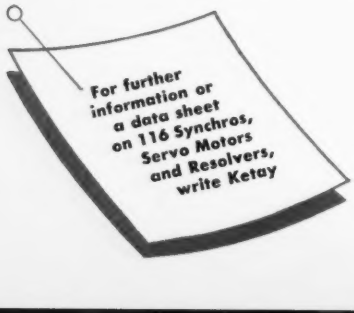
ADDITIONAL FACILITIES TO SERVE THE INDUSTRY



This plant, recently acquired at Commack, Long Island, adds air-conditioned work space that brings Ketay's total area to over 200,000 square feet, accommodating over 2,000 employees in the five divisions. Modern in every detail, the new plant has the latest equipment for precision volume production.

EXPERIENCE + RESEARCH + PERFORMANCE = LEADERSHIP

New developments and applications... increased facilities for volume production of components and complete systems... all the things reported on these pages are characteristic of Ketay—a firm with broad experience and specialized knowledge that adds up to leadership in the field of electrical devices and controls. This experience and knowledge is yours to command. In addition to synchros, servo motors and resolvers, it includes, but is not limited to: gyro components; aircraft engine instruments; computers; magnetic, resolver and synchro amplifiers; remote indicators and automatic control systems. Ketay's completely staffed and equipped Research and Development Division can be of greatest service during the design stage of applications involving Ketay products. You are invited to avail yourself of this service.



Ketay
MANUFACTURING CORP.

Executive Offices 555 Broadway, New York 12, N. Y.
Pacific Division, 12833 Simms Avenue, Hawthorne, California

New York Division • Kinetix Instrument Division • Pacific Division
Electronic Instrument Division • Research & Development Division

where, at 8:00 p.m., the meeting was opened by Chairman Alfred F. Stott. Mr. Stott expressed the appreciation of the members to Col. E. C. Greene, Professor of Air Science and Tactics at Illinois Institute of Technology, for making all arrangements for the meeting. Colonel Greene was aided by Cadet Moran, Chairman of the IAS Student Branch at Illinois Institute of Technology.

Mr. Stott then introduced Theodore Linnert, of the Airline Pilots Association, who in turn introduced the speaker of the evening, Carl Christenson, Director of Safety, United Air Lines, Inc. Mr. Christenson, a veteran pilot with many thousands of hours of flying time to his credit, spoke on the subject of "Complacency."

Mr. Christenson's talk was well received by his audience and was followed by an interesting question-and-answer period that went on for an additional half hour. The speaker was extremely thorough in answering all questions.

The meeting was closed by Chairman Stott at 10:15 p.m.

Hampton Roads Section

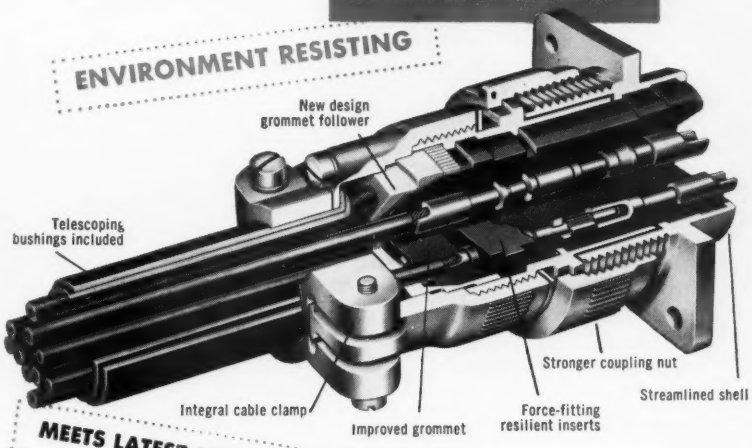
John E. Duberg
Recording Secretary

On February 1, more than 50 members and guests of the Hampton Roads Section of the IAS met in the Administration Building of the Langley Aeronautical Laboratory of the NACA. Chairman Herb Jackson introduced the speaker, Capt. Sheldon W. Brown, Head of the Overhaul and Repair Department at the Norfolk Naval Air Station. Captain Brown is a native of Toledo, Ohio, and a veteran Naval aeronautical-engineering-duty officer. Before entering Naval aviation, he served a tour of duty on the cruiser "Milwaukee" as a junior officer. He received his Navy wings in 1935, after completing flight training at Pensacola, Fla., and flew with Observation Squadron Two. Next followed duty as a bomber pilot on the carrier "Ranger" and then as a torpedo pilot on the old flattop "Lexington." Specializing in aeronautical engineering, he has served in the offices of the Under Secretary of the Navy, the Assistant Secretary of the Navy for Air, and the Bureau of Aeronautics.

In World War II, he was awarded the Secretary of the Navy's commendation for research and development planning. During his 3 years with the Bureau of Aeronautics, where he was Director of the Ships Installation Division, he was credited with assisting in the development of the canted deck, the high-capacity steam catapult, and the new barricade emergency arrestment device now being accepted on the latest carriers.

NOW...the new CANNON AN-"E" PLUGS

ENVIRONMENT RESISTING



MEETS LATEST MILITARY SPECIFICATIONS

Streamlined Shell Approximately 25% lighter than previous design.

Stronger Coupling Nut Improved strength features.

New Grounding Lugs Integral; convenient.

Integral Cable Clamp Space saving, fewer parts.

New, lighter polychloroprene... or Cannon's new exclusive premium Silcan 63, optional, featuring resilience, increased tensile strength, and long-lasting dimensional stability.

***Closed-entry* socket contacts,** machined from solid high-conductivity copper alloys, silver-plated; hand tinned solder pots.

Telescoping Bushings Standard Equipment

No moisture condensation trap
The Cannon AN-"E" Connector grommet provides positive seal against the rear of the resilient insulator. Mating surfaces of resilient insulators of connectors are sealed by compressing the insulators 3/32" during mating. AN-"E" Connectors have 3 times the flashover value of similar connectors, sealed. An important feature for high altitude and other applications.

AN3108E Plug mated with AN3102E Receptacle

Moisture proof!
...Vibration resisting!
...Resilient insulation!

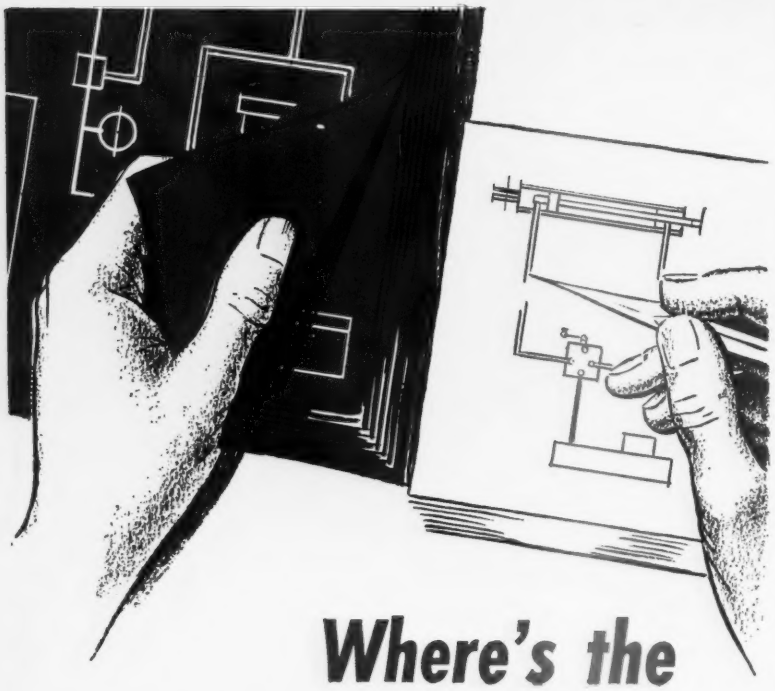
Just what you've been waiting for!
The new high-quality, streamlined, simpler, smaller, and lighter Cannon AN-"E" meets today's military specifications (MIL-C-5015A ASG) with improved connector performance. *Completely sealed from cable to cable.* A multi-service unit designed to meet your moisture condensation, flashover, corona, and vibration problems.

Write for "AN-E" Bulletin... TODAY!

Refer to Dept. 105

CANNON ELECTRIC COMPANY, 3209 Humboldt St., Los Angeles 31, California. Factories in Los Angeles; East Haven; Toronto, Canada; and London, England. Representatives and distributors in all principal cities.

Since 1915 CANNON ELECTRIC



Where's the Hydraulic Problem That Can't Be Solved?

We've been looking for the hydraulic problem that can't be solved—and as yet we haven't found it! Through the years, many leading aircraft builders have come to us, saying they had hydraulic applications that couldn't be made to work. Find the answers? Working together, we did!

Electrol INCORPORATED
HYDRAULICS
KINGSTON, NEW YORK
Telephone, Kingston 1980

CYLINDERS • SELECTOR VALVES • FOLLOW-UP VALVES
CHECK VALVES • RELIEF VALVES • HAND PUMPS
POWERPAKS • LANDING GEAR OLEOS • SOLENOID
VALVES • ON-OFF VALVES • SERVO CYLINDERS • TRANSFER
VALVES • CUT-OUT VALVES • SPEED CONTROL VALVES

This work brought him the Navy's Legion of Merit award last September. He holds a Master of Science and Professional Degree in Aeronautical Engineering from the California Institute of Technology. Captain Brown is also an Associate Fellow of the Institute of the Aeronautical Sciences.

Such a background in carrier flight and design enabled the speaker to discuss the general problem of the take-off and landing from carriers of naval aircraft with considerable authority. He traced the history of design requirements for arresting aircraft on flight decks from the relatively modest ones of the early propeller-driven aircraft to the stringent ones imposed by the heavier high-speed jet aircraft. The latest development is the canted-deck carrier using high-capacity steam catapults for launching. Such a deck has increased the equivalent length of runway of World War II carriers from 8,000 to 12,000 ft. and will make the new Forrestal equivalent to 14,000 ft. The canted deck, by clearing the forward deck, has freed more space for longer catapults. It has also provided the aircraft pilot with more freedom in carrier landings; this has resulted in more relaxed pilots and smoother landings. Since longer catapults and smoother landings impose lighter loads on the airframe, the possibility exists for weight savings on several aircraft frames.

A motion picture was shown illustrating flight operations from the canted-deck carrier "Antietam."

Los Angeles Section

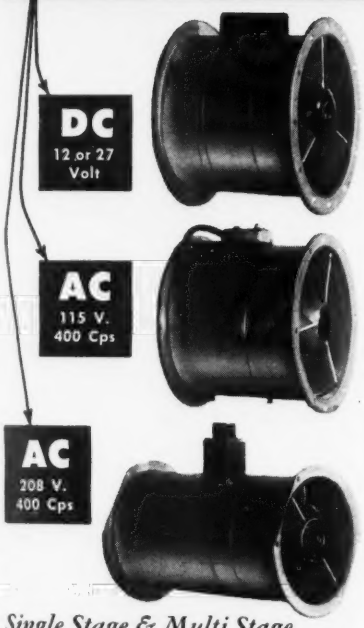
Evert C. Hokanson
Secretary

Our National President, J. L. Atwood, honored the Los Angeles Section by addressing the February 18 dinner meeting. He told of the IAS Twenty-Second Annual Meeting and Honors Night Dinner in New York. Mr. Atwood then introduced the speaker, Raymond H. Rice, Vice-President and Chief Engineer of North American Aviation, Inc. Another honored guest was Dr. Theodore von Kármán, Chairman of the Advisory Group for Aeronautical Research and Development, NATO.

Mr. Rice's subject was "Supersonic Booms." This intensely interesting phenomenon is created by shock waves from an airplane at supersonic speed under appropriate atmospheric conditions. When these shock waves are propagated to the ground, they are heard as explosive noises (supersonic booms).

The first supersonic boom was analyzed as such in March, 1950, near Dayton, Ohio, when Col. Richard

Your
BLOWER PROBLEM
is our
BUSINESS



Single Stage & Multi Stage
Diameters 2" thru 20"

- HIGH PRESSURES
- HIGH EFFICIENCY
- LIGHT WEIGHT
- COMPACT PACKAGE
- SPECIAL SHAPES
- DEPENDABILITY

Since 1942 we have specialized in Aircraft and Electronic Blower Applications. This 12 years of "Know-How" is yours when you call us in on your Blower Requirements.

We have 100 Active Models which can be adapted to your specific requirements.

We manufacture the entire unit, including the motor, so responsibility for warranty rests squarely with us and schedules are met.

"THE BLOWER YOU NEED *IS* GUARANTEED!"

DYNAMIC AIR ENGINEERING *Inc.*
7412 Maie Avenue, Los Angeles 1, California

Johnson, of Wright-Patterson AFB Test Center, while performing a series of routine dive tests, reached approximately 1.05 Mach Number. It has been determined that above the speed of sound a pattern of shock waves is attached to the airplane. As the airplane slows down to subsonic speed and pulls out of the dive, these shock waves pass forward over the airplane and travel down toward the ground. Usually the normal atmospheric variation of temperature with altitude causes these shock waves to curve upward. A temperature inversion will, however, cause the shock wave to curve downward.

Sonic booms caused by airplanes diving at speeds slightly above the speed of sound have been annoying, but they have not caused any appreciable damage, because the supersonic portion of the dive has been performed far away from observers. This may not be the case when aircraft performance is increased, and level supersonic flight can be maintained at low altitude. This was recently proved during a demonstration at the Palmdale (Calif.) Airport when a YF-100 made low-level passes over the Administration Building. In addition to causing a loud explosion and raising dust on the field, 0.25-in. thick plate-glass panels in the doors were shattered, and the door frames were cracked. The glass was blown in the same direction as the flight path of the airplane. This indicated the possibility of using low flying supersonic aircraft in military offensive action. Light structures may be exceedingly vulnerable to this type of attack.

Low flying at supersonic speeds, Mr. Rice explained, takes a great deal of pilot skill and advance planning. Hence, it is inconceivable that friendly aircraft will ever inadvertently cause damaging sonic booms.

Richard Heppe, Section Chairman, presided at this meeting, which was attended by over 400 members and guests.

▶ Robert A. Needham, Associate Engineer at the University of California at Los Angeles, addressed the February 11 Specialist Meeting on "A New Simplified Method for Predicting Crippling Stresses in Structural Shapes." He presented a new concept of local crippling based upon angle elements rather than plate elements of a complex shape. This method accurately predicts maximum allowable compressive stress for formed or extruded structural shapes of various materials. Prepared comments by F. R. Shanley were read following Mr. Needham's paper.

▶ Dr. Leo Stoolman, Aerodynamics Advanced Design Group of Hughes Aircraft Research and Development Laboratories, gave a paper on "Characteristics of Ram-Jets" at the February 23 Specialist Meeting. This paper covered

Jet Aircraft
TEMPERATURE MEASURING
The *Systems with*
JETCAL
TESTER

• The JETCAL *quickly* tests the exhaust gas temperature (EGT) thermocouple circuit of a jet aircraft or pilotless aircraft missile for error *without running the engine or disconnecting any wiring.*

The JETCAL also has these corollary purposes:

A) To isolate errors in the EGT system.

B) To check thermocouples for continuity.

C) To be used in "tabbing" or "micing" . . . and to give accurate temperature readings for checking the setting of fuel control or automatic nozzle area openings.

D) To check the thermocouple harness ring on the engine before its installation in the airframe.

E) To separately test the EGT indicator using the potentiometer and special circuit of Jetcal

F) To functionally test overheat detectors and wing anti-ice systems (thermoswitches) by using TEMPCAL* Probes.

JETCAL Tester is guaranteed accurate to ±4°C. at engine test temperature.

Now used by U. S. Navy and Air Force as well as by major aircraft and engine manufacturers.

• The production or maintenance engineer, pilot and *cost accountant* will readily assay the safety and savings factors resulting from Jetcal use. *We invite inquiries concerning the Jetcal Tester . . . and will be glad to have our engineering department help solve your heat problems.*

*Available separately at extra cost.

b&h INSTRUMENT

B & H INSTRUMENT
Company, Inc.
1009 Norwood
FORT WORTH 7, TEXAS

Douglas Aircraft Corp., is only one of many users who have found that Dalohm precision power resistors offer every desirable characteristic — smallest in size; sealed in silicone; 100% impervious to moisture; complete welded construction; TC. 0.00002/Deg. C; resistance ranges to 55,000 ohms; tolerances 0.05% to 5%.

used in the DC-7...

DALOHM RH-250 (250 Watts)

RH-Types (also available in 50 and 25 watt sizes) silicone sealed in die-cast radiator finned housing, and mount on sub-panel for maximum heat dissipation.

write • wire • or call

1324 28th Ave. Phone 2139

DALE PRODUCTS, INC.

Columbus, Nebraska, U. S. A.

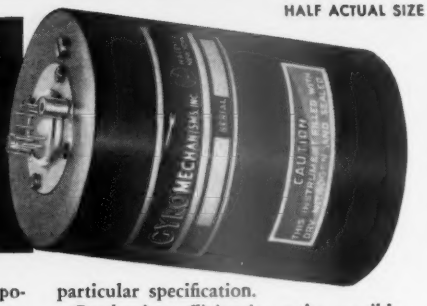
In Canada — Teletronics Corp. Ltd., Toronto and Montreal

new DALHOLM "RUGGEDIZED" RESISTORS

Type RSE resistors (available in 2, 5 and 10 watt sizes) made to withstand the utmost in shock conditions. Every Dalohm characteristic PLUS housed in metal for clip mounting.

HALF ACTUAL SIZE

ANGULAR RATE MEASURING GYROSCOPES



PRECISION, ruggedized units, incorporating extremely low threshold values and fine resolution. The units have an unusually favorable ratio of gyroscopic to transverse inertia, resulting in the highest values of undamped natural frequency. This is achieved through a unique type of construction.*

An inherently linear viscous damper unit is employed, and, due to its small size, only a minimum amount of electrical power is required to maintain it at its thermostated temperature, and very rapid initial warm-up is achieved. Damping coefficient can be readily supplied over a wide range to meet your particular specification.

Production efficiencies make possible unusually short delivery schedules and a low unit price.

POWER INPUT: 400 cps., either single or three phase, 26 v. or 115 v.

SENSITIVITIES: 15°/sec. max. to 400°/sec. max.

OUTPUT, Any of Three Types:

A.C. obtained through variable reluctance pickoff.

D.C., obtained through case-contained R.F. circuitry and capacity pickoff

A.C. or D.C., obtained through high resolution, precious metal potentiometer.

WRITE FOR LITERATURE

GYROMECHANISMS, INC.

HALESITE • LONG ISLAND • NEW YORK • HUntington 4-6330

*PATENTED

GYROSCOPES · POTENTIOMETERS · ELECTRONIC AND HYDRAULIC DEVICES FOR INSTRUMENTATION AND CONTROL

a résumé of the theory of ram-jet propulsion with special emphasis on the appropriate separation of internal and external force systems and the determination of significant aero-thermodynamic parameters that govern performance. The phenomenon of diffusor instability was discussed. Well-chosen slides added interest to the presentation.

Montreal Section

Gordon Rosenthal, *Secretary*

Professor John D. Akerman, Head of the Aeronautical Engineering Department at the University of Minnesota, was guest speaker at a dinner meeting held on February 1 in the Main Dining Room of the International Aviation Building. The speaker was introduced by G. Rosenthal. Although the main topic of the evening was "Supersonic Research at the Rosemount Laboratories," Professor Akerman also spoke on his recent visit to the IAS-RAeS Joint Conference and the SBAC Air Show, Farnborough, England.

The Rosemount Laboratories' growth was traced from birth to its present stages. An outline of the philosophy of the Laboratories' direction and staff selection was given. A summary of the unclassified projects currently under development was also given. The projects particularly mentioned were the corona discharge method for turbulence investigations, hot-air ejectors, and cleaning and cooling of exhaust gases.

A remarkable color film showing the Laboratories in aerial views as well as close-up scenes of wind tunnels and test apparatus was then shown.

After a brief discussion period, Professor Akerman turned to his impressions of the SBAC Air Show and the British aircraft firms that he visited. He was most impressed by the accomplishments of the British aircraft industry with the little resources at their disposal. He encouraged the sharing of information and facilities on both sides of the ocean.

Following these remarks, a film on the SBAC show, obtained through the courtesy of Ernest Stout, of Convair, was shown, as were some color slides taken at the same show. These were well received by the audience.

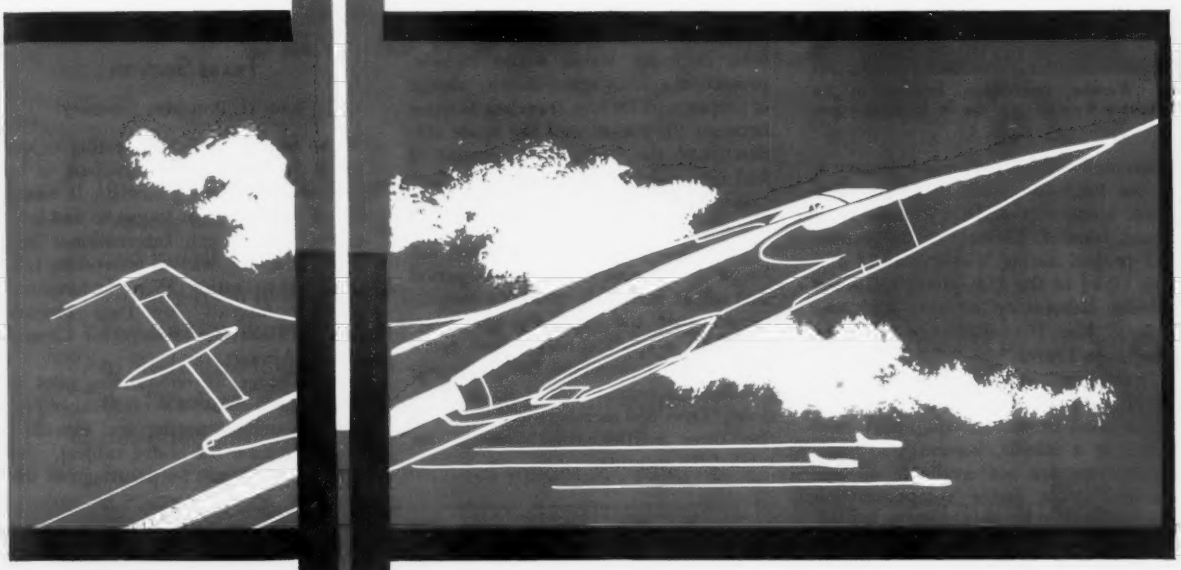
W. K. Ebel, Vice-President of Engineering, Canadair, Ltd., thanked the speaker. A. E. Ades, Section Chairman, then adjourned the meeting.

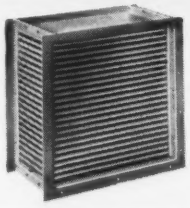
St. Louis Section

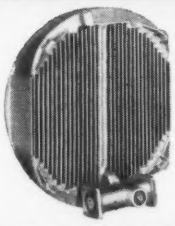
G. S. Graff, *Secretary*

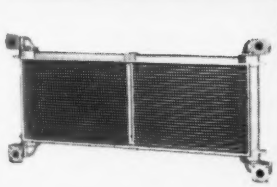
The February meeting of the St. Louis Section was held in cooperation with the Society of Automotive Engineers and the Engineers Club of St.

TEMPERATURES MADE TO ORDER!









Ground temperature—*a sweltering 95°!* Five minutes later and forty thousand feet higher—*a frigid 40° below!* Yet Harrison oil coolers keep engine temperatures under control—at sea level or miles up in the air. That's because Harrison heat exchangers are engineered for the job. They're compact, durable—designed to save space, save weight. Save money, too! On roads and rails—on water and in the air, you'll find Harrison heat exchangers doing a maximum cooling job at minimum operating expense. If you have a hot or cold problem . . . look to Harrison for the answer!

HARRISON

RADIATOR DIVISION
GENERAL MOTORS CORP.
LOCKPORT, N. Y.

Dr. Wernher von Braun, Speaker at the February 4 meeting of the St. Louis Section.

Louis on Thursday evening, February 4, at the Engineers Club Building. The guest speaker was Dr. Wernher von Braun, formerly Director of the German V-2 project during World War II and now Chief of the U.S. Army's Guided Missile Laboratory at the Redstone Arsenal, Ala. His subject was "Rockets and Space Travel."

In discussing guided missiles, Dr. von Braun pointed out that a missile designer must design all equipment contained in a missile, inasmuch as such components are not available on the market. This factor comprised the chief difficulty in designing a guided missile. Dr. von Braun then raised a question about the reliability of such a missile since equipment so designed is of necessity relatively new and untried and therefore lacks a time-tested background.

By way of illustrating that difficulties are not caused by complexity of design alone, the speaker cited as an example a dial telephone system, which, though very complex, achieves its steady reliability by the use of components whose durability has been proved.

After a parting jest at the expense of airplane designers who have only to pick their components out of catalogs and analyze their aerodynamic problems from information in NACA and industry reports and in handbooks (a comforting statement, if it were only true), Dr. von Braun discussed some aspects of space travel and its attendant difficulties. He proposed a three-stage rocket that could be used to establish a space station a little over 1,000 miles above the earth's surface. Such a station would not only enable the entire globe to be kept under 24-hour surveillance as the space station encircled the earth once every 2 hours but would also serve as an excellent base for a lunar expedition. From the space station, Dr. von Braun estimated that it would take 5 days to reach the moon, and then, after circling it, an additional 5 days to return. The only requirement for power in a trip from the space station to the moon and back would be in the initial phase to get the space ship started. Once started, the ship would then "coast" to the moon and back in an elliptical path.

Dr. von Braun opined that the most difficult aspect of establishing a space station would be the trip back to earth. The difficulties of the return trip would be the same as some of those encountered in designing present-day aircraft, i.e., stability and control at supersonic speeds and the effects of elevated temperatures on structures. Other problems in space travel would include: protection against space debris; design of proper suits for men traveling in space between the rocket and the space station; and the tremendous amount of fuel required for small pay loads (approximately 165 lbs. of fuel per lb. of pay load).

Dr. von Braun's formal talk was followed by a question-and-answer period that substantiated the speaker's opening remark that the physical task of establishing a space station would probably be easier than convincing a group of Missouri engineers that it could be done. Over 350 members and guests of the three participating societies attended the meeting.

San Diego Section

H. C. Matteson
Corresponding Secretary

Design problems and compromises in the pressurizing and air-conditioning system of a modern fighter airplane was the subject for a technical meeting held at the San Diego IAS building on the evening of February 25. The speaker was George A. Lemke, Design Specialist, Convair, San Diego.

Mr. Lemke has been with Convair since 1939, and his positions have included that of Chief Test Engineer, Assistant Project Engineer, and Design Group Engineer. Over the past 4 years he has been devoting his major effort to the problems associated with the design of air-conditioning and pressurization systems. He utilized this experience to present his subject in a comprehensive and thoughtful manner.

Mr. Lemke opened his discussion by pointing out that the modern fighter airplane with its transonic and supersonic operating speeds, its extreme operational altitude, and its heavy load of electronic gear presents a severe cooling and air-conditioning problem. The solution of this problem, he said, has a direct and significant effect on the airplane performance. The speaker then proceeded to discuss the equipment required to accomplish the necessary cooling and air conditioning, and various means of arranging this equipment. During his talk, Mr. Lemke emphasized the more critical aspects of the design and the attendant necessity for considering design compromise in order to avoid excessive complication, weight, and airplane-performance penalties.

Mr. Lemke's informative and well-rounded talk was enjoyed by an audience of approximately 75 members and guests. A lengthy question-and-answer period followed the prepared talk. Coffee and doughnuts were served at the close of the meeting.

Texas Section

John H. Boucher, *Secretary*

The regular monthly meeting of the Texas Section for January had to be postponed until February 4. It was a dinner meeting open to guests and held at the Fort Worth International Airport. Featured was an interesting talk on "Flight Testing High Performance Military Aircraft" by Paul Thayer, Sales and Service Manager of Chance Vought Aircraft, Inc.

Mr. Thayer, an outstanding pilot in this area and always a lively speaker, presented some interesting and revealing information on the above subject. He introduced his talk by pointing out the relativity of performance in aircraft. Ten years ago, a fighter with 350 to 400 knots maximum speed, 8,000- to 10,000-ft. rate of climb, and combat ceiling of 30,000 to 40,000 ft. was considered a high-performance airplane. Now with the advent of the gas-turbine engine and the current advances in aerodynamics, structures, and equipment these performance characteristics are many times what they were 10 years ago and are continually improving.

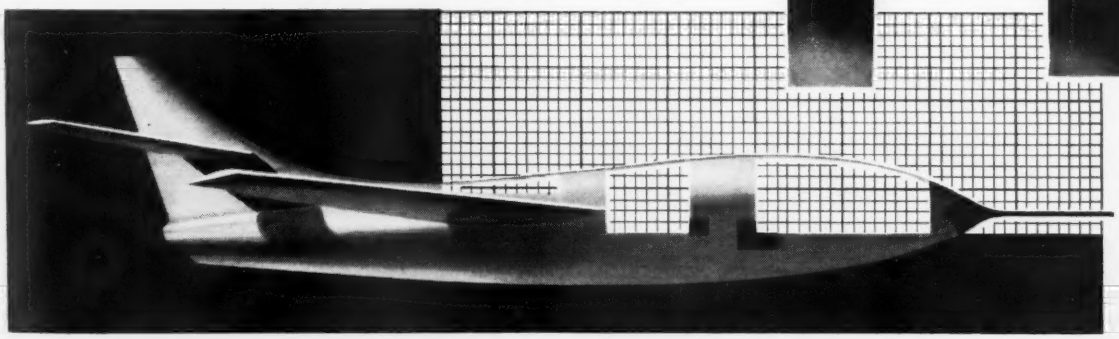
The most important performance parameters in an airplane, Mr. Thayer stated, are level flight speed, maneuverability, combat altitude, combat radius, acceleration in level flight, rate of climb, and landing and take-off performance. The emphasis on these performance parameters depends upon particular type and mission of the aircraft, and to avoid confusing the issue, Mr. Thayer confined his discussion to fighter-type aircraft.

It was pointed out that each of the above performance characteristics is largely dependent on weight-to-thrust ratio, with this factor usually making or breaking the airplane in the eyes of the combat pilot. If the airplane has the performance, pilots will usually put up with deficiencies in stability, control, etc., which might border on being dangerous; however, they will positively not accept airplanes with medium or low

PUTTING THE PIECES TOGETHER

JET STYLE!

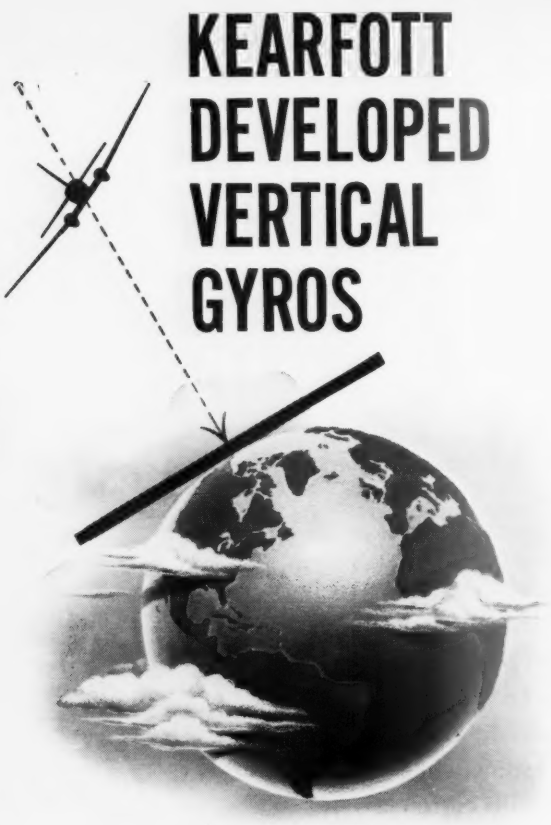
The assembly of components by the Redux® Bonding Process has made possible for the first time the design and building of the most advanced types of jet aircraft directly from the drawing boards without a prototype. The de Havilland "Comet" is the outstanding example of Redux bonded commercial aircraft today, while the "Cutlass" F7U3 fighter is among aircraft currently designed in the United States specifically for the Redux Process. Reduced structural weight . . . fatigue



strength . . . airtight joints of high shear and peeling strength . . . lower production costs . . . provide the many reasons why Redux Bonding is being so widely adopted as standard procedure for turbo-jet, jet, and rocket production. Complete information may be obtained from . . . Plastics Division, Ciba Company Inc., 627 Greenwich Street, New York 14, N. Y.

CIBA **REDUX** BONDING PROCESS

"OPENING A NEW ERA IN AIRCRAFT ENGINEERING"



KEARFOTT DEVELOPED VERTICAL GYROS

...in production

KEARFOTT vertical gyros providing continuous vertical reference within two minutes of arc under bench conditions typify the engineering knowhow and production skills available to you in the field of precision gyros for airborne control applications.

Designed for particular applications with stringent performance requirements, a wide variety of vertical gyros now in production are being used extensively in aircraft and missile control systems demanding the most precise gyro reference obtainable.

Kearfott gyros incorporate many unique features permitting operation under extreme operational or environmental conditions. A true hermetic seal in dry inert gas provides positive environmental protection. Synchro pick-offs and rigid structural elements assure performance during adverse conditions of vibration or shock.

TECHNICAL DATA SHEETS

Complete technical data in tabular form on Kearfott Precision Vertical Gyros are available on request. Send for copies for your files. Write today.

KEARFOTT COMPONENTS INCLUDE:

Gyros, Servo Motors, Synchros, Servo and Magnetic Amplifiers, Tachometer Generators, Hermetic Rotary Seals, Aircraft Navigational Systems, and other high accuracy mechanical, electrical and electronic components.

Technical Data on these and other components is available on request.

Kearfott SINCE 1917

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.

Sales and Engineering Offices: 1378 Main Avenue, Clifton, N. J.
Midwest Office: 188 W. Randolph Street, Chicago, Ill. South Central Office: 6115 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

A GENERAL PRECISION EQUIPMENT CORPORATION SUBSIDIARY

performance. Mr. Thayer described his experience with such an airplane during World War II where, despite some significant aerodynamic deficiencies, its outstanding low-altitude performance caused pilots to admire it.

The speaker brought out the fact that the effort and responsibilities of the contractor in developing a reasonably safe and operationally satisfactory airplane for the customers has increased proportionately to the performance and complexity increase in the new generation of airplanes. Where formally the contractor built two or three experimental airplanes to test the design and conduct the demonstration program, six or eight airplanes are now needed to compress this evaluation and development period into a time period compatible with operational requirements. It is now necessary to spend appreciably more time in developing and evaluating armament installations, fire control systems, and the complex hydraulic and electronic systems necessary for the tactical missions of high-performance military aircraft. The current aims of Mach 2.0 + speeds and 85,000- to 100,000-ft. altitudes with the attendant thermal-barrier problems will tend to compound the existing problems of flight testing.

Mr. Thayer next summarized his ideas on high-performance flight-testing programs in the modern era by pointing out some of the current and future problems. He stressed the importance of pilot safety with the fact that there is no point in putting a pilot in an airplane during any phase of a flight-test program unless we can expect to talk with him on his return. Such new and complex equipment as ejection seats and pressure suits are now required to protect the pilot. Even these can only be considered interim features when it is considered that tomorrow's airplanes will undoubtedly achieve 100,000-ft. altitudes and thereby will involve ejection problems of extreme heat and cold probably only solvable through the use of some kind of ejection capsule.

Getting back to today's airplanes, Mr. Thayer described the usual procedure in the initial flight-test program for a new airplane. He explained the obvious necessity in first evaluating the low - speed handling characteristics. After these have been determined to be reasonably safe, it next becomes desirable to spot check the overall performance envelope of the airplane as rapidly as possible, stopping only for possible safety of flight modifications. By following this procedure, all major deficiencies are exposed at an early date so that all problems resulting can be solved simultaneously instead of individually, thus avoiding the common

maintenance-free, heavy duty

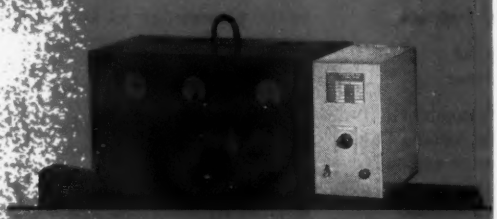
A.C. TO D.C. REGULATED

POWER SUPPLIES

- for production line testing
- laboratory testing
- pre-flight check-out of electronic equipment
- engine starting
- anodizing, electro-plating, etc.

For better VOLTAGE REGULATION from your present D.C. generator with

HUFFORD ROTA-MAG



This new Hufford development improves performance of all D.C. generators by providing *superior voltage regulation up to the full generator capacity!*

With suitable generators performance is equivalent in electrical characteristics to the most modern power supplies!

ROTA-MAG is complete, self-contained, ready to mount. It may be adjusted for any generator output voltage.

REGULATION: ±1% over full rated generated capacity.
RESPONSE: 0.2 second with application of full load.

Literature available!

Hufford Electronic Division announces a complete line of heavy-duty, regulated D.C. power supplies. Available in portable or stationary types, these units operate from either 220 or 440 volt, 3 phase, 60 cycle A.C. mains and are available in any desired output voltage and current ratings.

features

EXCELLENT VOLTAGE REGULATION—Within ± 1% from no load to full load, with line voltage fluctuations of ± 10%.

FAST RESPONSE—Recovery time under extreme load changes within 0.2 seconds.

LOW RIPPLE—Filter section effectively removes A.C. ripple to less than 1% r.m.s.

These power supplies are equipped with *magnetic amplifier voltage regulators* which are wear-free, extremely rugged, reliable and completely insensitive to vibrational damages or burn-out failures.

Built-in forced air cooling system insures efficient operation at full loads. General design emphasizes neat, in-line assembly and wiring, improving accessibility of all components. Quotations on individual requirements gladly given.

HUFFORD MACHINE WORKS, INC. *Electronics Division*

2201 CARMELINA AVENUE, LOS ANGELES 64, CALIFORNIA

tendency to emphasize only the deficiency that happens to be popular at the moment. Items that must be covered during this period include qualitative and quantitative evaluation of stall characteristics; longitudinal, lateral, and directional stability and control; both static and dynamic powerplant performance; cooling and afterburner operation; and high Mach Number characteristics. Mr. Thayer felt that all of these, except the high Mach Number investigations, could be handled similar to past procedures. While the high Mach Number investigations have become somewhat easier to handle due to the higher thrust engines now available, he felt that many of the problems that will be encountered in testing future airplanes will be in the high Mach Number high-altitude régime, the science of which is only now being developed.

Mr. Thayer's talk was well received by an interested audience, who undoubtably left the meeting with a much better appreciation of modern flight test problems.

Twin Cities Section

F. J. Ross, *Secretary*

The meeting of January 21 was called to order by Chairman Dave Mellen at the American Legion club rooms. The Secretary read the minutes of the last meeting (December 17), so that all members would be cognizant of the newly elected officers. These officers are as follows: Chairman, Dave Mellen; Vice-Chairman, Robert A. Hoel; Treasurer, Wesley Fisher; Secretary, F. J. Ross; Advisory Board, Orin Johnston, Les Schroeder, Harold R. Harris, J. D. Akerman, Don Benson, and A. E. Cronk; and National Council Representative, Frank Cook.

Chairman Mellen then appointed the following committees: Program and Planning, T. W. Chase, Chairman, K. G. Anderson, Art Jones, Rudolf Hermann, L. W. Sheridan, Roger Bowden, Ernest Poston, and Tung-Sheng Liu; Membership, Harold Road, Chairman, and Robert Hipps; and Nominating, A. E. Cronk, Chairman, L. L. Schroeder, and Don Benson.

Before introducing Ernest Stout, of Consolidated Vultee Aircraft Corporation, as the guest speaker, Frank Cook presented him with the "Octave Blau Knute Award" in recognition of the hazards of coming to the Twin Cities when the outside air temperature was somewhere in the order of −20° F.

After the award was presented to Mr. Stout, he was introduced by Chairman Mellen to the audience as the speaker of the evening. Mr. Stout gave an excellent talk, supplemented with slides and movies, on the development and current trends of water-based aircraft. The meeting was then adjourned.

Washington Section

T. C. Muse, *Secretary*

A joint meeting of the Washington Sections of the Institute of the Aeronautical Sciences and American Helicopter Society was held at the Burlington Hotel the evening of February 2. A social hour and dinner preceded the meeting.

The technical session was opened by Capt. W. C. Fortune, USN, Chairman of the Washington Section, IAS, who introduced Capt. J. N. Murphy, USN, Executive Director for Research and Development, Navy Bureau of Aeronautics, Mr. Benson, father of the principal speaker, and Jack Thompson and Thomas H. Purcell, Co-Owner and Chief Engineer, respectively, of Benson Aircraft Corporation, Raleigh, N.C. Captain Fortune also introduced the officers of the Washington Section of the IAS. He then turned the meeting over to Col. W. B. Bunker, Chief, Air Transport Division, Office, Chief of Transportation, U.S. Army, who introduced the American Helicopter Society officers and Brig. Gen. B. F. Hayford, Deputy Chief of Transportation U.S., Army, who was the Presiding Chairman for the meeting.

General Hayford introduced Igor B. Benson, President of Benson Aircraft Corporation, the speaker of the evening. Mr. Benson had for his topic, "Review of Fundamentals of Helicopter Propulsion." He listed the different types of power plants available for helicopters and briefly reviewed the merits and advantages of each. This was followed by a discussion of the theoretical efficiencies that could be expected from the difficult propulsion systems.

After completing his talk, Mr. Benson proceeded to demonstrate some of the principles he had previously discussed by flying two model helicopters about the dining room. One model used small pneumatic motors to drive propellers which in turn drove a two-bladed rotor. The propellers were located about one-third of the rotor semispan from the rotor hub. The other model had two cold-air jets located at the tips of the rotor blades. Both models flew and maneuvered very well, and the audience was delighted with the demonstration. To show further how easy it was to fly the models, Miss Billie Timm, Secretary of the Washington Section, AHS, and Colonel Bunker were able to solo the models after only about one minute of instruction.

Student Branches

Cal-Aero Technical Institute

Gary N. Wagner
Secretary-Treasurer

The Cal-Aero Student Branch held its January 14 meeting at the Airlane Cafe in Burbank. After a most enjoyable dinner, the meeting got under way.

The newly elected Chairman, Ed Lundby, was presented to the attending members by the outgoing Chairman, James N. Bishop. Mr. Lundby in turn presented the new Vice-Chairman, William F. Wennhold, and the new Secretary-Treasurer, Gary N. Wagner.

Our Faculty Advisor, Harris L. Bode, gave a brief speech of gratitude to the outgoing officers and then presented our guest speaker of the evening, E. W. Robischon, Manager of the IAS Western Region. Mr. Robischon gave an enlightening talk on the problems encountered upon entering the aircraft industry and how to overcome them. The informal speech was greatly appreciated by all.

Next, the film, *We Saw It Happen*, was shown. It depicted the development of the airplane from the Wright Brothers to the present-day jet aircraft. It was heartily enjoyed by everyone.

California State Polytechnic College

Daniel P. Hickey
Corresponding Secretary

The January 21 meeting was called to order by Chairman Robert Garrison who turned the meeting over to Recording Secretary Jack Gresham. Secretary Gresham then introduced the speaker, D. K. Warner, Flight Test Group Leader, North American Aviation, Inc., to the group of 70 faculty members and students attending.

Mr. Warner gave a talk entitled "World Speed Records" in which he traced the history of speed records from the first one made in a Curtiss biplane to the present-day record established in an F-100A Super Sabre. Particular emphasis was placed on the establishment of the F-100A's record. The speaker showed three films: *F-100A Super Sabre*, *F-86 Sabre*, and *Moonshine Squadron 523*.

The meeting was adjourned, after which refreshments were served.

For more than thirty years, The Liquidometer Corporation has concentrated almost exclusively on the research, design, manufacture, installation and service of liquid quantity measurement systems.

CAPACITOR TYPE FUEL QUANTITY GAGES • LIQUIDENSITOMETERS TO PROVIDE TRUE FUEL WEIGHT INDICATION • FLOAT ACTUATED GAGES MINIATURE COAXIAL CABLE CONNECTORS • POSITION TRANSMITTERS • POSITION INDICATORS • FLOAT SWITCHES • LIQUID LEVEL WARNING SWITCHES • LIQUID LEVEL CONTROLS • CENTER OF GRAVITY CONTROL SYSTEMS AND OTHER INSTRUMENTATION

THE LIQUIDOMETER CORP. LONG ISLAND CITY 1, NEW YORK

Shown during the January 21 meeting of the California State Polytechnic College IAS Student Branch, *left to right*, are: Daniel Hickey, Corresponding Secretary; Wayne Hester, Treasurer; Jack Gresham, Recording Secretary; Robert Garrison, Chairman; D. K. Warner, Flight Test Group Leader, North American Aviation, Inc.; Gene Neil, Vice-Chairman; and L. W. Gustafson, Head, Aeronautical Engineering Department, California State.

The Catholic University of America

Robert E. Kastner, *Secretary*

On Wednesday evening, January 20, the Catholic University of America Student Branch of IAS held its second meeting of the year. William Elsen, Chairman, introduced the speaker of the evening, Edward King, of Bendix Aviation Corporation. Mr. King spoke on the recent developments in all-weather navigation. First of all, he traced the history of instrument flying from the 1920's, when only compass and altimeter were available, to the institution of the common system in 1947 which is in partial effect at the present time. He also went into the workings of the I.L.S. (Instrument Landing System). He concluded with a description of the things to come in all-weather navigation.

▶ On Wednesday evening, February 10, the Student Branch held its third meeting of the year. The speaker for the evening was William St. Germain, of Boeing Airplane Company. He spoke on "New Developments and Applications of Boeing Gas Turbines." First, he explained the workings and performance of the Boeing gas turbine under numerous conditions. He emphasized the light weight per horsepower, the high torque producing capabilities, and the numerous applications for this type of an engine. Mr. St. Germain then showed two films on the use of the gas turbine. One demonstrated the turbine's use in an ordinary trailer truck. The other film was on the use of the gas turbine in a Kaman helicopter. The meeting was adjourned upon the conclusion of this film.

Illinois Institute of Technology

Jerry E. Hubacek, *Secretary*

The IAS Student Branch at the Illinois Institute of Technology was recently reactivated.

The current officers of this Branch are: Chairman, Edward Moran; Vice-Chairman, John Abell; Secretary, Jerry Hubacek; and Treasurer, Mel Wolf. The Faculty Advisor is Col. Edward C. Greene, Jr., USAF, Professor of Air Science and Tactics.

The Pennsylvania State University

Ralph N. Straley II, *Secretary*

A regularly scheduled meeting of The Pennsylvania State University Student Branch of the IAS was held on February 10 with 30 members attending. Chairman Frank Leader presided.

Allan McNally, our Banquet Committee Chairman, set the date for the forthcoming IAS Student Branch banquet as March 10. Chairman Leader then explained about the IAS student conference to be held at the Massachusetts Institute of Technology. After this announcement, the Chairman introduced the speaker of the evening, Dr. R. H. Waters, Professor in charge of the transportation major, Department of Commerce, Business College.

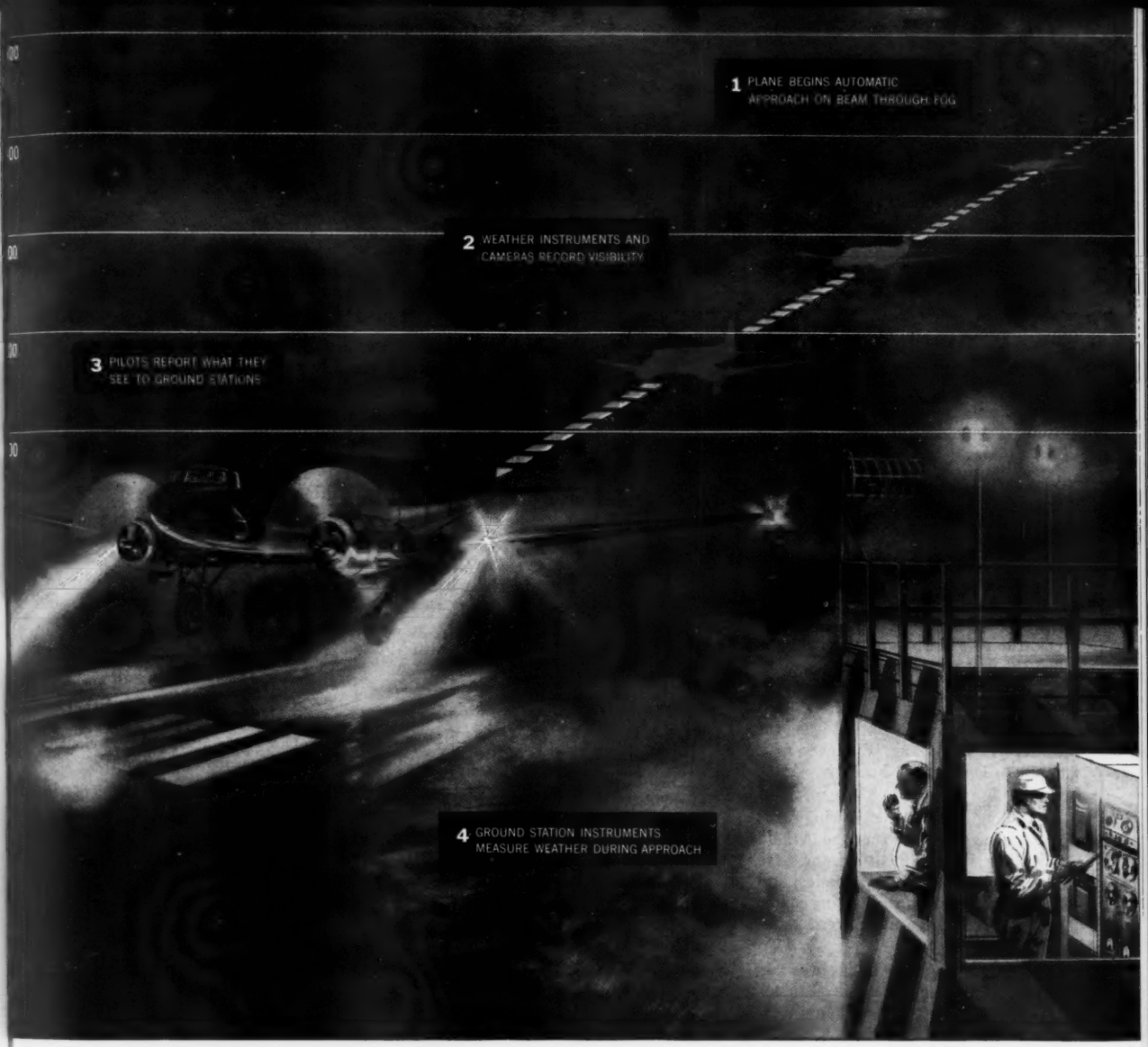
Dr. Waters spoke on "Government Subsidy of Air Transportation." The highlights of his excellent talk were direct mail subsidy, indirect airways subsidy, and landing facilities subsidy.

After a discussion period, the meeting was adjourned.

▶ The regularly scheduled meeting of February 24 was held on the Penn State campus with 35 members present. Chairman Leader presided.

Banquet Committee Chairman McNally announced the change in the date of the banquet from March 10 to March 11. The banquet is to be held at the Allencrest Tea Room in State College.

Shown during a recent inspection tour of the University of Florida's 1- by 1-in. supersonic wind tunnel are *(left to right)* John W. Hoover, Associate Professor of Aeronautical Engineering, and the following Student Branch officers: Hermann Reichmann, Chairman; Eugene Land, Treasurer; and Marion Dees, Vice-Chairman. Not shown in this picture is Shirley Van Patten, Secretary of Florida's Student Branch.


1 PLANE BEGINS AUTOMATIC APPROACH ON BEAM THROUGH FOG
2 WEATHER INSTRUMENTS AND CAMERAS RECORD VISIBILITY
3 PILOTS REPORT WHAT THEY SEE TO GROUND STATIONS
4 GROUND STATION INSTRUMENTS MEASURE WEATHER DURING APPROACH

Flying Lab makes 500 Landing Approaches in "Pea Soup"

THE STORY BEHIND THE STORY:

■ IF YOU'VE BEEN a passenger in a plane "stacked" above a fogged-in airport—or if you've been the pilot at the controls—you were certainly interested in headlines like the above appearing in newspapers a few months ago.

■ Behind those headlines is the dramatic story of men flying when "even the birds are walking," making landing approaches over and over again, to make your future landings safer in bad weather.

■ Working with the Air Navigation Development Board and the U. S. Weather Bureau, Sperry flight research personnel have completed 500 bad weather landing approaches in a flying laboratory equipped with specialized instruments. In flight, both manual and automatic recordings are made of conditions encountered during the final 500 feet of descent.

■ On the ground, trained observers report what they see, and monitor automatic instruments which measure ceiling and visibility conditions existing in the runway approach zone. Synchronized and analyzed, these records reveal the accuracy of the instruments and establish a wealth of information so pilots will know what weather to expect along the line of descent.

■ Because of its many years of experience in low ceiling approaches, Sperry was selected by the government to make the weather measurement study. This project is typical of the exacting flight research which is continuous at Sperry—flight research not only to perfect Sperry instruments and controls, but to advance the operational efficiency of both commercial and military aircraft.

SPERRY GYROSCOPE COMPANY

DIVISION OF THE SPERRY CORPORATION • GREAT NECK, N.Y.

The speaker will be a member of the staff of the Speech Department of the university.

A film, *Latest North American Aircraft*, was then shown, after which the meeting was adjourned.

United States Naval Academy

Midshipman Robert J. Hemings, Jr.
Secretary

On February 22, approximately 125 members made a field trip to the Smithsonian Institution and to the Washington (D.C.) National Airport. We made a tour of the Smithsonian and later heard a short lecture by some airport employees. Vice-Chairman George Cicolani and Officer-Representative Lt. E. C. Atkinson managed the trip.

University of Florida

Shirley Van Patten, *Secretary*

Chairman Hermann Reichmann called the first meeting of the second semester to order on February 15. A business meeting was held, after which Chairman Reichmann introduced the speaker, W. D. Poling, Engineer with the Gas Dynamics Facility, ARO, Inc.

Mr. Poling spoke of the growing pains of an organization such as the Arnold Engineering Development Center. He told us the political, economic, and historic background of this testing center and described some of its current problems.

The need for such a testing center was seen in 1944 by General H. H. Arnold. General Arnold set up a committee, headed by Dr. Theodore von Kármán, to study the problem. Through the findings of this committee and the efforts of General Arnold, the project was started. Now, 10 years later, the center is just entering the operational stage.

Mr. Poling discussed the center's three divisions, viz., the Engine Test Facility, the Gas Dynamics Facility, and the Wind Tunnel Propulsion Test Facility. He brought out problems that had been encountered by his department and told how they had been met.

After the meeting was adjourned, the group made an informal inspection of the supersonic wind tunnel in the University of Florida's laboratory.

University of Maryland

John J. Gallagher, *Secretary*

On January 13, we were privileged to have Dr. Hermann H. Kurzweg, Chief of the Aeroballistic Research Department of the Naval Ordnance Laboratory, White Oak, Md., speak to us on the trends in aeroballistic research. Dr. Kurzweg is a noted authority in the field of hypersonic tunnels. He was the Director of Research at the wind tunnels at Kochel, Bavaria, during the war. He has been in charge of the modernization of these tunnels since their installation at NOL. After the meeting was adjourned, Dr. Kurzweg joined in a discussion, answering many questions of the members.

Virginia Polytechnic Institute

Milton L. Windler, *Secretary*

At a joint meeting of the local student branches of the IAS and Sigma Gamma Tau on February 18, the aeronautical seniors oriented underclassmen on the VPI aeronautical laboratory. Subsonic pressure distribution on a Clark-Y, attached and detached shock waves in the supersonic tunnel, and strain gage applications were demonstrated to the large group that included many non-aeronautical students. Other equipment was also shown and briefly explained.

▶ At the March 2 meeting, plans were made for the branch's part in VPI's annual Engineering Emphasis Week (April 21–23). The film, *Jet Story*, was also shown.

West Virginia University

Richard E. Walters
Recording Secretary

Chairman Malcolm Ullock opened the meeting of February 17 with the election of officers for the second semester. The outcome of the election was: Chairman, Charles R. Bartlett; Vice-Chairman, Ben D. Grove; Recording Secretary and Treasurer, Paul C. Kramer; and Corresponding Secretary, Richard E. Walters.

After the election, Mr. Bartlett assumed the duties of Chairman and then introduced Professor Leon Z. Seltzer who gave an informative talk on the purposes and advantages of membership in the IAS Student Branch. Movies, *The Theory of Flight* and *The Theory of Propellers*, were shown after Professor Seltzer's talk.

Seventeen members and guests were present.

▶ The March 3 meeting was brought to order by Chairman Bartlett who welcomed and introduced the new members and visitors.

Subsequent to a discussion on possible displays for an engineering show, a USAF film, *The Third Pillar*, was shown.

Twenty members and visitors were present.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Atkin, Edgar H., B.Sc., Devel. Engineer, Republic Aviation Corp.

Hughes, Samuel R., Chief Aerodynamicist, Supermarine Works, Vickers-Armstrongs, Ltd.

Jones, William P., D.Sc., Supt., Aerodynamics Div., Natl. Physical Lab. (England).

Poth, John P., V-P—Engineering, Engineering & Research Corp.

Schultz-Grunow, Dr. F., Dr. Sc. Techn., Ord. Prof. for Applied Mechanics, Dir. of Institute for Applied Mechanics, Technische Hochschule Aachen (Germany).

Sivells, James C., M.S. in E.E., Mgr., "B" Proj. Br., Gas Dynamics Facility, ARO, Inc.

Transferred to Associate Fellow Grade

Draley, Eugene C., B.A.E., Chief, Full-Scale Research Div., NACA, Langley Aero. Lab.; Member, NACA Subcommittee on Propellers for Aircraft.

Feigen, Morris, Ph.D. in Engineering, Member of the Technical Staff, Hughes Aircraft Co.

Hochfeld, Henry, M.E., V-P—Engineering, Micromatic Machine Corp.

Murbach, J. Frederick, B.E., Dir., Patent Research Div., Manufacturers Aircraft Association, Inc.

Elected to MEMBER Grade

Arbuckle, Richard T., Design Engineer, Temco Aircraft Corp.

Bershader, Daniel, Ph.D., Assoc. Prof., Princeton Univ.

Braun, Chester V., B.S., Exp. Engineering Test Pilot, McDonnell Aircraft Corp.

Chana, William F., Service Engineer, Convair (San Diego).

Chapman, Walter R., M.S.M.E., Sr. Proj. Engineer, Thompson Products, Inc.

Christensen, Henry D., M.S. in M.E., Asst. Prof. of Aero. Engineering, Oregon State College.

Dickinson, Robert O., Jr., B.S.Ae.E., Group Engineer—Fuselage, Lockheed Aircraft Corp. (Georgia).

Eades, James B., Jr., M.S., Asst. Prof. of Aero. Engineering, Virginia Polytechnic Institute.

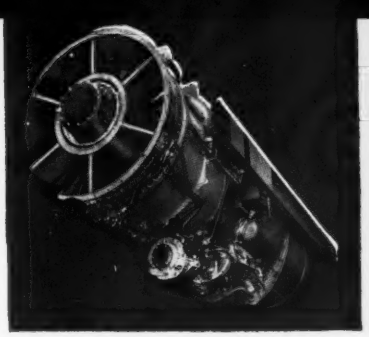
Fox, Jerome L., Ph.D.—Applied Math., Sr. Engineer, Research, Aerophysics Lab., North American Aviation, Inc.

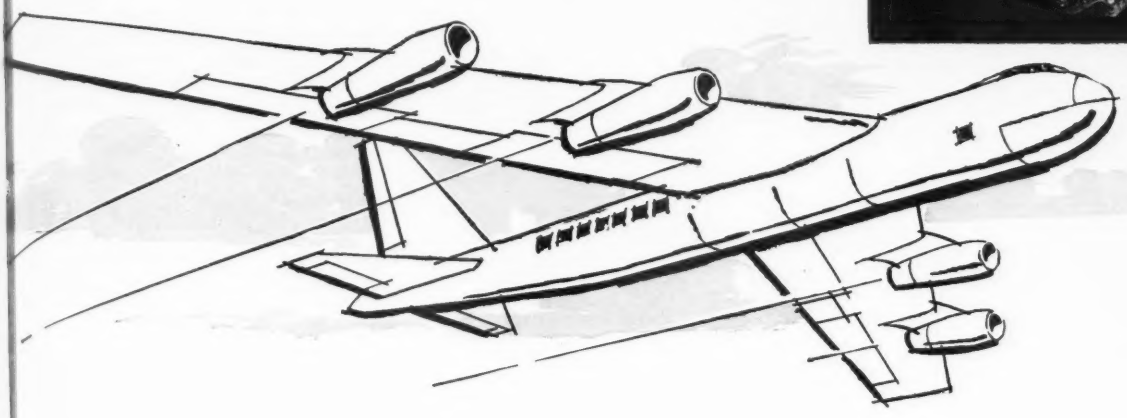
Francis, Ivan M., M.E., Proj. Engineer, Engineering Div., Chrysler Corp.

Franzel, Robert T., M.S. in Aero., Asst. to Dir. of Strategic Combat Systems for Guided Missiles, USAF, Hq., ARDC (Baltimore).

Cross Country in less than 4 hours...

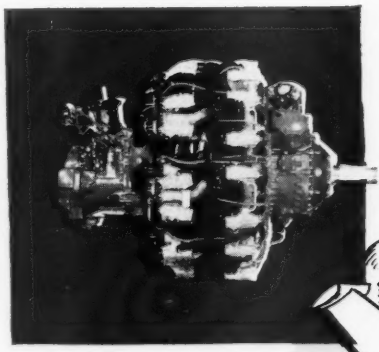
BY JET TRANSPORT





or Philadelphia to New York in less than 1 hour...

BY HELICOPTER



it's a sure bet you'll be riding with

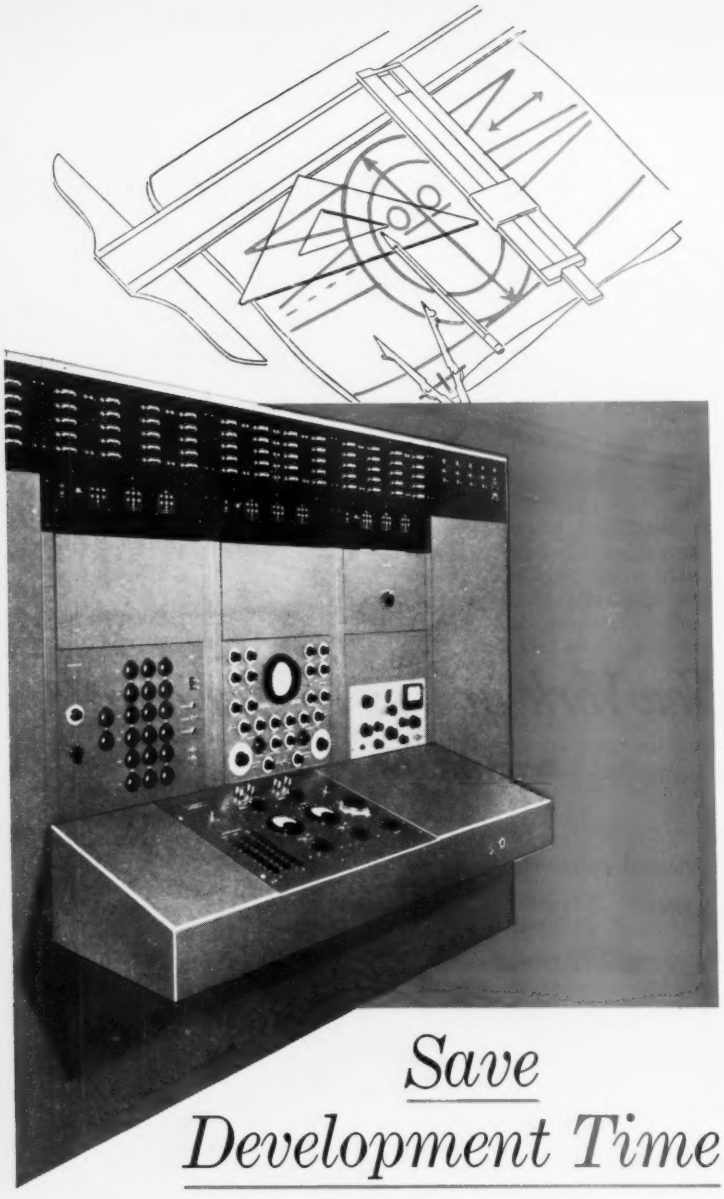
FOOTE BROS. AIRCRAFT-QUALITY PRECISION GEARS AND ASSEMBLIES

Leading producers of aircraft engines and air frames look to Foote Bros. when they need precision gearing and mechanical drives. Foote Bros. pioneering experience in the field, large engineering staff and complete production facilities make them the logical dependable source. Call or write today . . . Foote Bros. engineers are at your service.

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
4545 SOUTH WESTERN BOULEVARD, DEPT. G, CHICAGO 9, ILLINOIS



Save Development Time...

REDUCE COSTS

Evaluation of design without actual construction of preliminary models is today an engineering necessity. The MILAC Analog Computer makes this short-cut possible by rapid solution of mathematical-electronic models of new systems or structures. Different approaches and solutions may be tried out more freely, for the cost of construction and test of prototypes for each design change is eliminated. Development costs and engineering man-hours are thus vastly reduced, for the MILAC accurately predicts and rules out faulty designs before final performance tests.

To demonstrate the usefulness of the MILAC Computer in engineering design and analysis, Wm. Miller Instruments maintains an Analog Computing Service, available for solution of either a single design problem or an overall development program.

Detailed information about either the MILAC Computer or the Analog Computing Service will be sent on request.

WM PASADENA

WM MILLER INSTRUMENTS, INC.

CUSTOM INSTRUMENT DESIGNERS AND MANUFACTURERS

325 N. HALSTEAD AVENUE · PASADENA 8, CALIFORNIA · RYAN 1-6317

Garnett, Bernarr J., Asst. Chief Engineer, G. M. Giannini & Co.

Gruver, Dorsey B., Sr. Engineer—Design, North American Aviation, Inc.

Hall, Eldon W., B.M.E., Chief of Propulsion Systems Analysis Br., Lewis Flight Propulsion Lab., NACA.

Hansen, Harold S., B. of M.E., Mechanical Engineer, NAMTC (Pt. Mugu).

Herald, John M., Jr., B.S.M.E., Weapons System Engineer, Ryan Aeronautical Co.

Krase, William H., B.S.M.E., Thermodynamic Design Engineer, AGTD, General Electric Co.

Landstrom, Walter G., B.S.AeE., Struct. Engineer, Bell Aircraft Corp.

Minor, C. Dwight, Design Engineer, Convair (San Diego).

Plewes, Kenneth C., B.S. in M.E. Asst. Chief, Flight Data Br., USAF, Wright-Patterson AFB.

Statham, Louis D., B.A., President, Statham Laboratories, Inc.

Vaughan, John A., M.E., V-P—Research & Devel. Div., The W. L. Maxson Corp.

Washizu, Kyuichiro, B.E., Asst. Prof., Dept. of Applied Mathematics, Univ. of Tokyo; Special Graduate Student, Dept. of Aero. Engineering, Massachusetts Institute of Technology.

Wiant, Harry W., B.S.Ae.E. (Aero.), Proj. Engineer, Cook Research Lab.

Wieden, Camillo M., M.E., Chief, Prelim. Design, Gas Turbines, Fairchild Engine Div., Fairchild Engine & Airplane Corp.

Wokuluk, John J., Design Engineer, Convair (San Diego).

Zahorski, Adam T., Ph.D., Chief of Structures Div., Aerophysics Development Corp.

Transferred to MEMBER Grade

Boutelle, Albert, M.Sc. in Engineering, Asst. Chief Engineer, U. S. Rubber International.

Campbell, Mason H., M.S., Technical Engineer, Aircraft & Engine Performance, General Electric Co.

Cornwell, Roy S., B. of Ae.E., Lt. & Student in Aero. Engineering, USN, U.S. Naval Postgraduate School (Monterey).

Dickey, Paul I., B.Sc.Ae.E., Aerodynamics Engineer, Convair.

Gardner, Joseph P., M.S., Proj. Engineer, Aircraft Div., Rheem Manufacturing Co.

Harvey, Ray W., M.S.Ae.E., Supvr., Performance & Analysis Section, ARO, Inc.

Lane, William Henry, M.Sc., Resident Graduate Student, Dept. of Aero. Engineering, The Ohio State Univ.

Light, Russell B., B.S.Ae.E., Aerodynamicist "A," Boeing Airplane Co. (Seattle).

Steinle, Werner C., B.A.E., Sr. Proj. Engineer & Liaison Officer, Aerodynamics Lab., USN, David Taylor Model Basin.

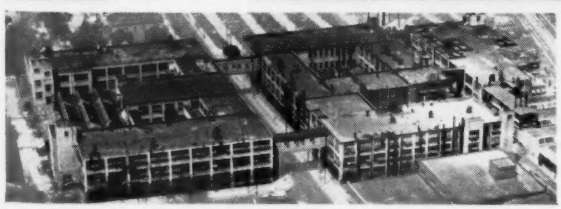
Good Management— key to America's defense...

. . . and good management is the key to AC's ability to turn out many of the electro-mechanical marvels which guard America's shores.

Through good management, engineers with the necessary training, experience and imagination can be used to best advantage. It takes good management again to provide these men with the specialized equipment and facilities they need—when and where they need them.

That kind of good management can build a "homing instinct" into antiaircraft shells—as AC is doing in the T-38 Skysweeper Fire Control Systems. AC is building pin-point accuracy into Gun-Bomb-Rocket Sights that are modern miracles of engineering and design.

AC is always looking for *new* problems in this field. If you have such a problem, good management may be the answer—and the "know-how" and experience of more than 700 AC engineers and scientists are at your service.



3,000,000 square feet of the most modern facilities in three huge AC plants—Dort Highway Plant in Flint, Industrial Avenue Plant in Flint, and the Milwaukee Plant.

GM GENERAL MOTORS GM GOOD MANAGEMENT

AC QUALITY PRODUCTS

AC SPARK PLUG DIVISION . . . GENERAL MOTORS CORPORATION, FLINT, MICHIGAN

DEFENSE PRODUCTS of High Quality at Low Cost DELIVERED ON TIME

Swihart, John M., B.A.E., A.B., Aero. Research Scientist, 16-Ft. Transonic Tunnel, NACA, Langley AFB.

Walker, Curtis Leroy, B.S. in M.E. (Aero.), Aero. Propulsion Systems Research Scientist, Lewis Flight Propulsion Lab., NACA.

Woodward, Frank A., A.E., Theoretical Aerodynamicist, A. V. Roe Canada, Ltd.

Zier, Avrum, Design Engineer, Republic Aviation Corp.

Elected to Associate Member Grade

Deckert, Harlan K., Jr., B.S., Supvr.—Engineering Admin. Services, Northrop Aircraft, Inc.

Eggleston, M. W., Test Engineer, Bendix Aviation Corp.

Forster, Charles Henry, Sub-Foreman Inspector, in Charge of Gas Turbine Test, A. V. Roe Canada, Ltd.

Livergood, Charles B., Technical Writer, North American Aviation, Inc.

Zisch, William E., V-P & General Mgr., Aerojet-General Corp.

Transferred to Associate Member Grade

Christ, Paul John, Jr., In Charge of the Parts Breakdown Group, Goodyear Aircraft Corp.

Elected to Technical Member Grade

Dickinson, Harry D., B.S.M.E., Proj. Engineer, G. M. Giannini & Co.

Ford, William W., Jr., Drafting Engineer "A," Lockheed Aircraft Corp. (Georgia).

Hobberstad, Kendall E., Design Engineer, North American Aviation, Inc. (Los Angeles).

Jeude, Edward A., Jr., B.S.M.E., Design Engineer, Chance Vought Aircraft, Inc. (Dallas).

Kohl, Kenneth Charles, B.S.M.E., Jr. Design Engineer, Controls Group, Chance Vought Aircraft, Inc. (Dallas).

Liebner, Robert W., B.S. in M.E., Liaison Engineer "B," Lockheed Aircraft Corp.

Rouse, Robert G., Jr., Flight Test Coordinator, Grumman Aircraft Engineering Corp.

Transferred to Technical Member Grade

Allison, Robert L., B.S.—Aeronautics, 2nd Lt., USAF; Student Officer, 3301 Pilot Tng. Sqdn., Columbus AFB.

Arand, Edward M., Jr., Jr. Engineer-Draftsman "A," Northrop Aircraft, Inc.

Belden, James E., Engineering Draftsman—Stress Analyst, North American Aviation, Inc. (Los Angeles).

Bold, H. Erich, Tool Engineer, Grumman Aircraft Engineering Corp.

Boyajian, Ara M., B.S.E. (Aero.), Devel. Engineer, Hamilton Standard Div., United Aircraft Corp.

Brassard, Joseph A., Jr., B.S. in Ae.E., Engineering Trainee, Chance Vought Aircraft, Inc.

Burg, John R., B.S.—Aeronautics, 2nd Lt., USAF; Pilot Training, Columbus AFB.

Carey, Charles J., B.S. in Ae.E., 2nd Lt., USAF; Student Officer—Flight Training, Malden AFB.

Chudoba, Albert J., Liaison Engineer, Douglas Aircraft Co., Inc. (Torrance).

Clager, Robert L., B. of Ae.E., Flight Test Engineer, Republic Aviation Corp.

Clancy, Donald M., Flight Test Analyst "A," Douglas Aircraft Co., Inc. (Santa Monica).

Cohen, Murray, B. of Ae.E., Designer "A," Republic Aviation Corp.

Condrey, William R., B.S., Lead Designer, Chance Vought Aircraft, Inc.

Downing, Charles, S.B., Naval Officer Candidate, USN.

Drown, Clifford F., B.S. in Ae.E., Capt., USAF; Chief, Mfg. Methods Group, ATIC, Wright-Patterson AFB.

Drury, Philip E., B.S., Jr. Engineer, Douglas Aircraft Co., Inc. (Santa Monica).

DuBois, S. J., Jr. Engineer, Lockheed Aircraft Corp. (Burbank).

Edwards, Harold, Jr., B.S. in Ae.E., Jr. Engineer "B," Prod. Proj. Liaison Group, Boeing Airplane Co. (Wichita).

Fleishman, Morton R., B.S.E. in Ae.E., Graduate Student, Horace Rackham School of Graduate Studies, The Univ. of Michigan.

Front, John V., B.S.—Aeronautics, 2nd Lt., USAFR; Perf. Calc. of Engine Test Facility, Arnold Engineering Development Center.

Garcia, Victor R., E. in AeE., Stress Analyst "A," Douglas Aircraft Co., Inc. (El Segundo).

Gee, Jimwah, Analyst-Research Sr., Supersonic Wind Tunnel, Dept. 95, Group 13, North American Aviation, Inc. (Los Angeles).

Holmes, Kenneth A., B.S., Lt. (jg), Operation & Evaluation of Naval Aircraft, USN, NAAS (Kingsville).

Kapral, Joseph, B.S., Compressor Design Engineer, AGTD Division, Westinghouse Electric Corp.

Lindgren, Edwin E., Jr. Design Engineer, Convair (San Diego).

Looper, Henry M., Jr. Engineer-Draftsman "A," Northrop Aircraft, Inc.

Malene, John E., B.S.—Aeronautics, Design Engineer-Trainee, Goodyear Aircraft Corp.

Meyers, Hamilton A., Engineering Designer, North American Aviation, Inc. (Los Angeles).

Mobley, Frederick F., B.S., 2nd Lt., USAF; Asst. Proj. Engineer, Aircraft Lab., ADC, Wright-Patterson AFB.

Morse, Dana S., B.S. in Ae.E., Research Engineer, Transonic Aircraft Control Proj., Massachusetts Institute of Technology.

Moses, William G., Jr., B. of Ae.E., Drafting Engineer "B," Lockheed Aircraft Corp. (Marietta).

Orlando, Victor E., Exp. Engineer Design-Draftsman "B," Republic Aviation Corp.

Ortasse, Raphael, B. of Ae.E., Stress Analyst, The Glenn L. Martin Co.

Palluth, William F., 2nd Lt. & Pilot, USAF.

Patterson, Jerrold E., B.S. in Ae.E., Engineer, Aerodynamics Dept., McDonnell Aircraft Corp.

Perkins, Theodore E., B.S. (Aero.), Aerodynamicist "B," Chance Vought Aircraft, Inc.

Plummer, Charles P., Jr. Engineer, Wind Tunnel Model Design Section, Convair (San Diego).

Pumarejo, Amaury, B.S., 2nd Lt., USAF; Observer Training, Harlingen AFB.

Putnam, Leslie R., B.S., Aerodynamicist, Missiles Div., McDonnell Aircraft Corp.

Ramsay, James, Methods Engineer, Boeing Airplane Co. (Seattle).

Real, Mackey J., Jr., B.S., 2nd Lt., USAF; Student Pilot, 3305 Pilot Training Sq., Malden AFB.

Reisert, Donald, B. of Ae.E.

Sanders, Melvin C., Jr. Engineer-Draftsman "B," Northrop Aircraft, Inc.

Seely, William B., B.S. in Ae.E., Jr. Engineer, AGT Div., Westinghouse Electric Corp. (Kansas City).

Shore, Sherman, B.S.M.E.Ae.E., 2nd Lt., USAF; Jr. Aero. Engineer—Wind Tunnel, The Glenn L. Martin Co.

Skogstad, Paul H., S.B. & S.M., Aero. Engineer, Cornell Aero. Lab., Inc.

Walker, Ralph M., Jr., B. of Ae.E., Jr. Engineer, Aerodynamics Group, Convair (Ft. Worth).

Wang, Chiao Jen, Dr. Engineering, Research Engineer, North American Aviation, Inc. (Los Angeles).

Weideman, Walter H., Jr., Jr. Engineer "A," Aerodynamics Dept., Ryan Aeronautical Co.

Zuschlag, Henry R., Jr. Engineer-Draftsman "B," Northrop Aircraft, Inc.

The Most Trusted Name in Ignition

BACKED *by the finest service facilities in the industry.*

BACKED *by Scintilla Division field service specialists.*

BACKED *by efficient distributors.*

Whenever you specify Bendix ignition equipment, whether it be a complete ignition system or an electrical connector, you know that efficient performance is assured by a team of service experts unsurpassed in the industry.

Every Scintilla Division distributor has had the benefit of specialized training in service procedures, and also has at his command the services of a nation-wide field organization. Both the distributors and company field men are constantly kept up-to-date by the Scintilla Division Service Department in new and improved methods that will prolong equipment life and effect substantial maintenance economies.

Thus the policy of seeing that every customer gets the full performance built into each product is implemented by a competent and well-rounded service organization dedicated to keeping the name Bendix "The Most Trusted Name in Ignition."

SCINTILLA DIVISION

OF

Bendix

AVIATION CORPORATION

SIDNEY, NEW YORK

Bendix

AVIATION PRODUCTS

Low and high tension ignition systems for piston, jet, turbo-jet engines and rocket motors . . . ignition analyzers . . . radio shielding harness and noise filters . . . switches . . . booster coils . . . electrical connectors.

Export Sales: Bendix International Division, 205 East 42nd St., New York 17, N. Y.

FACTORY BRANCH OFFICES: 117 E. Providencia Ave., Burbank, Calif. • Stephenson Bldg., 6560 Cass Ave., Detroit 2, Mich. • 512 West Ave., Jenkintown, Pa. Brouwer Bldg., 176 W. Wisconsin Ave., Milwaukee, Wisc. • American Bldg., 4 S. Main St., Dayton 2, Ohio • 8401 Cedar Springs Rd., Dallas 19, Texas

MORE LEAR AUTOPILOTS WERE PRODUCED IN 1953 THAN ALL OTHER MAKES COMBINED!

CP-3

Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

I. PERIODICALS AND REPORTS

Aerodynamics 142
Boundary Layer and Thermoaerodynamics 142
Control Surfaces 142
Fluid Mechanics and Aerodynamic Theory 142
Internal Flow 142
Performance 142
Stability & Control 142
Wings & Airfoils 143
Aeroelasticity 143
Aeronautics, General 143
Airplane Design 144
Control Systems 144
Airports 144
Aviation Medicine 144
Computers 144
Education and Training 144
Electronics 144
Amplifiers 146
Antennas 148
Communications 148
Construction Techniques 148
Crystals 150
Dielectrics 150
Electronic Controls 150
Electronic Tubes 150
Magnetic Devices 152
Measurements & Testing 152
Networks 155
Noise & Interference 156
Oscillators & Signal Generators 156
Power Supplies 158
Radar 158
Semiconductors 158
Transmission Lines 158
Wave Propagation 158
Equipment 158
Electric 158
Hydraulic & Pneumatic 158
Flight Operating Problems 158
Fuels & Lubricants 161
Gliders 162
Ice Formation & Prevention 162
Instruments 162
Flow-Measuring Devices 162
Laws & Regulations 162
Machine Elements 162
Gears & Cams 162
Materials 162
Corrosion & Protective Coatings 162
Metals & Alloys 162
Mathematics 165
Meteorology 165
Military Aviation 166
Missiles 166
Navigation 166
Noise Reduction 166
Photography 166
Physics 167
Power Plants 167
Jet & Turbine 167
Reciprocating 168
Rocket 168
Production 168
Metalworking 168
Production Engineering 170
Tooling 170
Propellers 170
Reference Works 170
Rotating Wing Aircraft 172
Safety 172
Space Travel 172
Structures 172
Bars & Rods 172
Beams & Columns 174
Cylinders & Shells 174
Thermodynamics 174
Heat Transfer 176
Wind Tunnels & Research Facilities 176

II. BOOKS REVIEWED IN THIS ISSUE

Book Notes 179

Books, reports, and periodicals reviewed in this issue or in previous issues may be borrowed on 2-week loan without charge by individual or Corporate Members of the Institute in the U.S. and Canada. Members of The Paul Kollsman Lending Library who are not members of the Institute may borrow books and, in special cases, other research material. Members of the IAS may borrow also from the Engineering Societies Library through The Paul Kollsman Lending Library.

Photostatic copies of material in the Institute's libraries may be obtained at a cost of $0.35 to members and Corporate Members ($0.45 to nonmembers) for each 8½- by 11-in. print and $0.40 to members and Corporate Members ($0.50 to nonmembers) for each 11½- by 14-in. print, plus postage. A minimum charge of $1.00 is made to nonmembers of the IAS. Reference citations in the Aeronautical Reviews Section give the total number of pages for report and booklet materials; only the beginning page is given for periodical articles.

Bibliographies on special subjects will be compiled at the rate of $2.50 per hour. *Translations* of technical literature from foreign languages may be obtained at $12 to $14 per 1,000 words, depending on the language. IAS members receive a 20 per cent discount on bibliographies and translations.

Full information about library membership and facilities will be sent upon request to The Paul Kollsman Lending Library, 2 East 64th St., New York 21, N.Y.

Aerodynamics

Symposium on High Speed Aerodynamics; Summary of Proceedings, Ottawa, Can., Feb. 26–27, 1953. *Canada, NAE HSAL Rep.*, June, 1953. 76 pp. 34 refs. Contents: Application of Kinetic Theory to Fluid Flow, G. N. Patterson. One-Dimensional Unsteady Wave Interactions, I. I. Glass. High Mach Number Flows in Wind Tunnels, J. D. Stewart. Properties of the Contact Surface, J. G. Hall. Flow Round Compound Lifting Units, A. Robinson. Development of Transonic Wind Tunnel Testing Technique, J. Lukasiewicz and J. A. Laurmann. Design and Calibration of Supersonic Wind Tunnel Nozzles, J. G. LaBerge. Growth of Boundary Layer in Supersonic Nozzles, J. Ruptash. An Exact Solution for the Delta Wing, L. R. Fowell. A Study of the Rolling Pull Out Manoeuvre by the Inverse Method, Bernard Etkin and J. G. R. Collette. Heat Transfer Properties of a Laminar Boundary Layer in Supersonic Flow, N. Pridmore Brown. Wind Tunnels in the High Speed Aerodynamics Laboratory, J. Lukasiewicz.

Boundary Layer & Thermoaerodynamics

An Approximate Solution of the Compressible Laminar Boundary Layer on a Flat Plate. R. J. Monaghan. *Gt. Brit., ARC R&M 2760* (Nov., 1949), 1953. 24 pp. BIS, New York. $1.50.

Density Profiles of Subsonic Boundary Layers on a Flat Plate Determined by X-ray and Pressure Measurements. Ruth N. Weltmann and Perry W. Kuhns. *U.S., NACA TN 3098*, Feb., 1954. 30 pp. 13 refs.

The Determination of Turbulent Skin Friction by Means of Pitot Tubes. J. H. Preston. *J. RAeS*, Feb., 1954, p. 109. 16 refs. Development of a simple, accurate experimental method to measure the skin friction from readings of geometrically similar round pitot tubes located on the surface, for two- and three-dimensional flows.

Effect of Diffusion Fields on the Laminar Boundary Layer. John W. Smith. *J. Aero. Sci.*, Mar., 1954, p. 154. Theoretical analysis of the effect of steady-state diffusion fields on the dynamic and thermal characteristics of a laminar boundary layer on a flat plate in steady compressible flow.

Heat Transfer to Constant-Property Laminar Boundary-Layer Wedge Flows With Stepwise and Arbitrary Wall-Temperature Variation. Steve Scesa and Solomon Levy. *Trans. ASME*, Feb., 1954, p. 279. 11 refs.

Present Status of Information Relative to the Prediction of Shock-Induced Boundary-Layer Separation. Roy H. Lange. *U.S., NACA TN 3065*, Feb., 1954. 16 pp. 23 refs.

Boundary Layer Control by Distributed Surface Suction or Injection; Bi-Parametric General Solution. T. P. Torda. *J. Math. & Phys.*, Jan., 1954, p. 312.

A Flight Investigation of the Practical Problems Associated with Porous-Leading-Edge Suction. Paul A. Hunder and Harold I. Johnson. *U.S., NACA TN 3062*, Feb., 1954. 42 pp.

Control Surfaces

Esperienze in Galleria del Vento su di un Modello di Impennaggio Orizzontale con Equalibratore a Rotazione Vincolata e Libera (Wind Tunnel Tests on a Horizontal Tail Model with Fixed and Free Elevator). Mario Pittoni. *L'Aerotecnica*, Dec., 1953, p. 410. In Italian.

Raffronto tra i Risultati Sperimentali Ottenuti con due Modelli di Impennaggio Verticale Diversamente Proporzionati nei Loro Elementi Costitutivi (A Comparison Between the Experimental Results Obtained on Two Different Vertical Tail Models). Mario Pittoni. *L'Aerotecnica*, Dec., 1953, p. 414. In Italian.

Fluid Mechanics & Aerodynamic Theory

Applications of Hypersonic Small-Disturbance Theory. Milton D. Van Dyke. *J. Aero. Sci.*, Mar., 1954, p. 179. 22 refs. A study of the simplest inviscid theory retaining the essential nonlinearity of the hypersonic similarity rule of Tsien and Hayes.

Incompressible Flow Past a Sinusoidal Wall of Finite Amplitude. Carl Kaplan. *U.S., NACA TN 3069*, Feb., 1954. 26 pp. 10 refs. Analysis of mathematical difficulties in iterative procedures used.

On a Class of Viscous Compressible Flows. S. K. Lakshmana Rao. *J. Indian Inst. Sci., Sect. B*, Jan., 1954, p. 33.

Remarks on Film Condensation With Turbulent Flow. R. A. Seban. *Trans. ASME*, Feb., 1954, p. 299.

Supersonic Shocks. O. G. Sutton. *Aeronautics*, Feb., 1954, p. 36. Analysis of behavior patterns of shock waves in terms of audible "bangs."

A Theoretical and Experimental Study of the Shock Tube. I. I. Glass, W. Martin, and G. N. Patterson. *U. Toronto Inst. Aerophys. Rep. 2*, Nov., 1953. 281 pp. 73 refs. Analysis of relevant wave theory and wave interactions; production of strong shock waves; design and constructional criteria for shock tubes.

Turbulent Processes as Observed in Boundary Layer and Pipe. G. B. Schubauer. *J. Appl. Phys.*, Feb., 1954, p. 188. NACA-sponsored NBS investigation of the behavior and of the life cycle of turbulent motion in two distinctly different flow fields.

Undersökning av Noggrannheten vid Beräkningen av en Viss Dubbelintegral, som Förekommer i de Transoniska Integralekvationerna (Examination of the Accuracy of the Calculation of a Certain Double Integral which Occurs in the Transonic Integral Equation). Tore R. Gullstrand. *Stockholm, KTH Rep. FI 14*, Oct. 20, 1951. 36 pp. In Swedish.

Internal Flow

Beitrag zur Potentialströmung durch axiale Schaufelgitter. Wolfgang-Hermann Isay. *ZAMM*, Dec., 1953, p. 28. 11 refs. Analysis of flow through a lattice of blades by use of singular points distributed along the contour of the profiles.

Experimental Determination of Local and Mean Coefficients of Heat Transfer for Turbulent Flow in Pipes. I. T. Aladyev. (*Izvestiya Akademii Nauk SSSR, Otdelenie Tekhnicheskikh Nauk*, No. 11, 1951, p. 1669.) *U.S., NACA TM 1356*, Feb., 1954. 18 pp. 10 refs. Translation.

Problems and Results of Investigations on Cascade Flow. Hermann Schlichting *J. Aero. Sci.*, Mar., 1954, p. 163. 26 refs. A summary report of research on flows through cascades of airfoils at the Institute of Fluid Mechanics, Technical University of Braunschweig, Germany.

Some Aerodynamic Problems of Compressors and Turbines. William R. Sears and Wen-Hwa Chu. *U. Md. Inst. Fluid Dynamics & Appl. Math., Lecture Ser. 30*, Nov., 1953. 24 pp. 10 refs. Analyses of three major internal flow problems: the interference between cascade rows in relative motion; progressive rotating stall as a consistent solution of asymmetric flow; and airfoil characteristics after stall.

Study of Three-Dimensional Internal Flow Distribution Based on Measurements in a 48-inch Radial-Inlet Centrifugal Impeller. Joseph T. Hamrick, John Mizisin, and Donald J. Michel. *U.S., NACA TN 3101*, Feb., 1954. 64 pp. 18 refs.

A Summary of NACA Research on Heat Transfer and Friction for Air Flowing Through Tube With Large Temperature Difference. Benjamin Pinkel. *Trans. ASME*, Feb., 1954, p. 305. 28 refs.

Performance

British Performance Reduction Methods for Modern Aircraft. D. Cameron. *Gt. Brit., ARC R&M 2447* (Jan., 1948), 1953. 32 pp. *BIS*, New York. $1.90.

Energy Approach to the General Aircraft Performance Problem. Edward S. Rutowski. *J. Aero. Sci.*, Mar., 1954, p. 187. Analysis from the point of view of the balance between the potential and kinetic energy change of the aircraft, the energy dissipated against the drag, and the energy derived from the fuel.

Gust Accelerations & Airspeeds Experienced by Viking Aircraft in Scheduled Operations over Indian Routes. T. S. Krishnamurthy. *J. Aero. Soc. India*, Nov., 1953, p. 84. Analysis includes charts, tables, and diagrams on operational and performance data.

Stability & Control

Effects of Wing Position and Fuselage Size on the Low-Speed Static and Rolling Stability Characteristics of a Delta-Wing Model. Alex Goodman and David F. Thomas, Jr. *U.S., NACA TN 3063*, Feb., 1954. 66 pp. 20 refs.

Flight Tests on Swinging during Take-off on a Single-engined Fighter-bomber (Typhoon Ib). W. Stewart. *Gt. Brit., ARC R&M 2660* (Apr., 1948), 1953. 29 pp. BIS, New York. $1.80.

A Simple Mechanical Analogue for Studying the Dynamic Stability of Aircraft Having Nonlinear Moment Characteristics. Thomas N. Canning. *U.S., NACA TN 3125*, Feb., 1954. 18 pp.

The Theoretical Effect of Flight Path Angle on the Lateral Stability and Response of an Aircraft. E. M. Frayn and M. V. Parnell. *Gt. Brit., ARC R&M 2529* (Nov., 1945), 1954. 28 pp. BIS, New York. $1.70.

Wings & Airfoils

Corrections for Symmetrical Swept and Tapered Wings in Rectangular Wind Tunnels. W. E. A. Acum. *Gt. Brit., ARC R&M 2777* (Apr., 1950), 1953. 33 pp. BIS, New York. $2.00.

Limiti di Convenienza nell'Impiego della Freccia Alara a Velocità Supersonica (On the Limitations to the Convenience of Using Swept-back Wings at Supersonic Speeds). Antonio Eula. *L'Aerotecnica*, Dec., 1953, p. 393. In Italian.

The Pressure Distribution, at Supersonic Speeds and Zero Lift, on some Swept-back Wings having Symmetrical Sections with Rounded Leading Edges. G. M. Roper. *Gt. Brit., ARC R&M 2700* (Feb., 1949), 1954. 20 pp. BIS, New York. $1.25.

Theoretical and Experimental Investigations of Interference Effects of Delta Wing-Vertical Tail Combinations with Yaw. Willi Jacobs. *Sweden, Flygtekniska Försöksanstalten, FFA Meddelande NR 49*, 1953. 34 pp. 15 refs.

The Theoretical Wave Drag at Zero Lift of Fully Tapered Swept Wings of Arbitrary Section. T. Nonweiler. *Coll. of Aeronautics, Cranfield, Rep. 76*, Oct., 1953. 49 pp.

Aeroelasticity

Extension of Power Spectral Methods of Generalized Harmonic Analysis to Determine Non-Gaussian Probability Functions of Random Input Disturbances and Output Responses of Linear Systems. Bernard Mazelsky. *J. Aero. Sci.*, Mar., 1954, p. 145. 10 refs.

Graphical and Numerical Investigation of Forced Vibrations of a Nine-Mass System. W. Kurzemann. *Engr. Dig.*, Feb, 1954, p. 51. Application of the vector-diagram method.

Supersonic Theory for Oscillating Wings of Any Plan Form. W. P. Jones. *Gt Brit., ARC R&M 2655* (June, 1948), 1953. 11 pp. BIS, New York. $0.90.

Vibration Damping Characteristics of Glass Fiber Cushioning. Sol Musikant. *Prod. Eng.*, Feb., 1954, p. 166. Developmental, design, and service factors.

Vibration Isolation of Equipment With Eccentric Centers of Gravity. Sheldon E. Young. *Prod. Eng.*, Feb., 1954, p. 146. Selection factors for three-point, four-point, and six-point mountings.

Aeronautics, General

IAS 22nd Annual Meeting, New York, Jan. 25–29, 1954. Summary of Technical Sessions. I. *Aero. Eng. Rev.*, Apr., 1954, p. 40. Contents: Aeroelasticity—I, Martin Goland. Rotating Wing—I, Edward F. Katzenberger. Aeroelasticity—II, I. E. Garrick. Rotating Wing—II, R. Williams. Aerodynamics—I, W. R. Sears. Aerodynamics—III, C. C. Furnas. Meteorology, H. R. Byers. Aeronautical Engineering Education, John W. Hoover. Aircraft Design, Ernest G. Stout. Motorless Flight, Ben Schupack. Aerodynamics—IV, Francis H. Clauser. Rocket Propulsion, James J. Harford. Flight Safety, Jerome Lederer.

Yes, in a way, a second helping—for we are trying to express the factors which have helped raise the AMERICAN PHENOLIC CORPORATION by its boot straps in a little over twenty years. In the early thirties AMPHENOL was just another struggling industrial infant in one small factory and our main concern then was radio sockets. Today there are five modern plants producing over 11,000 catalogued products ranging all the way from AN connectors to television antennas. "A little more of everything"—we think a little more courage, a little more imagination, a little more faith have been responsible for the growth of AMPHENOL during the last two decades. And we look forward to the same "little more" qualities, a second helping of the same, to keep AMPHENOL a vital member of the electronics industry for many, many years to come.

AMERICAN PHENOLIC CORPORATION
Chicago 50, Illinois

AMPHENOL

Airplane Design

Aerodynamic Effects on Cabin Altitudes. E. G. D. Maynard. *J. Av. Med.*, Dec., 1953, p. 491. Analysis of flight test results for an F-86 aircraft.

Design Analysis of the (Handley Page Crescent-Winged) Victor. Peter Scott. *Av. Age.*, Feb., 1954, p. 24. Includes factors of wing layout, torsion and flexing, fuel system arrangement, speed, altitude, and range.

Evoluzione Tecnica dei Mezzi di Trasporto Aereo (On the Technical Evolution of Transport Aircraft). Giovanni P. Casiraghi. *L'Aerotecnica*, Oct., 1953, p. 330. 320 refs. In Italian. A 31-page survey of design, structural, aerodynamic, and other factors related to the development of essential characteristics of speed, safety, comfort, and economy, with an extensive bibliography.

A Medium-range French Airliner. James Hay Stevens. *The Aeroplane*, Feb. 5, 1954, p. 154. Structural design, equipment and accessories, control systems, operational characteristics, and other technical features of the SNCASE S.E.210 Caravelle.

Un Metodo di Calcolo delle Sollecitazioni nell'Atterramento di un Aereo a Carrello Triciclo (A Method for the Calculation of Stresses During the Landing of an Airplane with Tricycle Landing Gear). Antonio Del Salvatore. *L'Aerotecnica*, Dec., 1953, p. 424. In Italian.

Modern Twin-Engined Transport Aircraft. Peter Berry. *Aeronautics*, Feb., 1954, p. 24. Evaluative survey of airline operational experience.

Pressure Refuelling; A Modern Method and its Advantages: The Components Described and Explained. A. W. Goodliffe *Flight*, Feb. 5, 1954, p. 148.

Self-landing and the Crescent Wing. R. S. Stafford. *The Aeroplane*, Feb. 5, 1954, p. 149. Analysis of the Handley Page Victor's landing characteristics.

The Winjeel. Ian H. Ring. *Aircraft* (Australia), Jan., 1954, p. 22, cutaway drawing. Design and constructional details of the basic trainer.

Control Systems

. . .Functional Aspects of Design. C. L. Bates. *Prod. Eng.*, Feb., 1954, p. 129. Evaluative analysis of operational and system characteristics, human factors, and environmental conditions in the testing of the primary flight control system of an airplane.

Pilot's Viewpoint of Turbojet Control Requirements. Robert E. LaCroix. *Skyways*, Mar., 1954, p. 10. Optimum control-system design criteria, with operational and reliability factors.

Powered Flying Controls—The Present Position. F. J Bradbury. *Aeronautics*, Mar., 1954, p. 58. Developmental survey, with evaluations of various systems; design trends.

Airports

Application of Simulation Techniques in the Study of Terminal-Area Air Traffic Control Problems. C. M. Anderson and T. K. Vickers. *U.S., CAA TDR 192*, Nov., 1953. 29 pp.

Eliporti (Heliports). Renato Vannutelli. *L'Aerotecnica*, Dec., 1953, p. 401. In Italian. Factors of location, size, approaches, facility design and construction, and other requirements to facilitate establishment of heliports.

New Demands on Airport Ground Services. Miles Thomas. *Aeronautics*, Mar., 1954, p. 36. Performance of aircraft related to ground operations.

Aviation Medicine

Animal and Human Reactions to Rapid Tumbling. H. S. Weiss, R. Edelberg, and J. I. Rosenbaum. *J. Av. Med.*, Feb., 1954, p. 5. 21 refs.

The Effects of Drugs Upon Psychological Efficiency. Robert B. Payne. *J. Av. Med.*, Dec., 1953, p. 523. 11 refs.

The Effects of Monocular Blind Areas in Visibility from Aircraft. George O. Emerson. *J. Av. Med.*, Dec., 1953, p. 518. 13 refs.

A New Device for Measuring the Effects of Continuous Positive Pressure Breathing on Lung Volumes and Ventilation. Alfred L. L. Bell, Jr., and James E. Wood. *J. Av. Med.*, Feb., 1954, p. 67. For high-altitude flight studies.

Some Observations on Aircrew Fatigue in the RCAF—Tokyo Airlift. S. D. McGrath, E. D. Wittkower, and R. A. Cleghorn. *J. Av. Med.*, Feb., 1954, p. 23. 14 refs.

Some Observations on Human Tolerance to Accelerative Stress. IV–Human Tolerance to High Positive G Applied at a Rate of 5 to 10 G per Second. E. L. Beckman, T. D. Duane, J. E. Ziegler, and H. N. Hunter *J. Av. Med.*, Feb., 1954, p. 50. 13 refs.

Studies on the Electrophysiology and the Metabolism of the Retina. Werner K. Noell. *USAF SAM Project 21-1201-0004 Rep. 1*, Oct., 1953. 121 pp. 148 refs.

Time Consumption of Eye Movements and High-Speed Flying. S. J. Gerathewohl and H. Strughold. *J. Av. Med.*, Feb., 1954, p. 38.

Studies in Motivation of Student Aviators at the Naval School of Aviation Medicine. John T. Bair and Edwin P. Hollander. *J. Av. Med.*, Dec., 1953, p. 514.

There'll Always Be a Man. Alfred H. Lawton. *J. Av. Med.*, Dec., 1953, p. 532. Human factors of flight problems.

Computers

Analog Computing by Heat Transfer. Paul H. Savet. *Tele-Tech*, Feb., 1954, p. 101. Application of heat-electrical transducers to the design of computer, servo-control, and instrumentation circuits.

Diode-Capacitor Memory for Computers. Arthur W. Holt. *Radio & TV News, Radio-Electronic Eng. Sect.*, Feb., 1954, p. 20. (Also in *U.S., NBS Tech. News Bul.*, Nov., 1953, p. 171.) NBS-developed high-speed reliable information-storage device.

Electronic Analogue Computing; Survey of Modern Techniques. Raymond B. Quarmby. *Wireless World*, Mar., 1954, p. 113.

FOSDIC—A Film Optical Sensing Device For Input to Computers. *U.S., NBS Tech. News Bul.*, Feb., 1954, p. 24. (Also in *Tele-Tech*, Feb., 1954, p. 78.) A data reader for translating up to 10 million answer positions per hour.

Frequency Analysis of Digital Computers Operating in Real Time. John M. Salzer. *Proc. IRE*, Feb., 1954, p. 457. 16 refs.

Problems Involved in Magnetic Tape Recording. Norman E. Gibbs. *Audio*, Mar., 1954, p. 19. ONR-sponsored investigation of magnetic tape defects applied to pulse reproduction used as computer memory elements.

"REAC" Computer Reliability. Bernard Loveman. *Tele-Tech*, Mar., 1954, p. 79. Experience data from the NavBuAer Project Cyclone Simulation Lab. at Reeves Instrument Corp. to develop a guided-missile simulator; design, operational, and other factors.

Education & Training

Personnel Training Required to Produce Large Quantities of High-Performance Aircraft. Leverett P. Wenk. *Aero. Eng. Rev.*, Apr., 1954, p. 53. Engineering training programs at Republic Aviation Corp. and elsewhere.

Training the Royal Air Force Apprentice. R. J. Carvell. *J. SLAE*, Jan., 1954, p. 5.

Electronics

Cooling Electronic Equipment in Supersonic Aircraft; How to Get Cooling and Heating from the Same Fuel. Doyle C. Wells. *Ryan Reporter*, Jan. 15, 1954, p. 10.

Design of a Continuously Variable Low-Pass Filter Utilizing Negative Feedback Techniques. Basil T. Barber. *Audio*, Mar., 1954, p. 26. Application of the concept of Laplace transforms and the principles of negative-feedback theory to derive the filter design equations.

The Effect of Tension on the Thermoelectric Properties of Metals. A. J. Mortlock. *Australian J. Phys.*, Dec., 1953, p. 410. 16 refs.

FM Transient Response of Band-Pass Circuits. R. E. McCoy. *Proc. IRE*, Mar., 1954, p. 574. Derivation of a general formula for the output voltage resulting from an abrupt frequency shift to determine the instantaneous frequency deviation; applications include telemetering circuits.

A General Solution of the Two-Frequency Modulation Product Problem. I. R. L. Sternberg and H. Kaufman. *J. Math. & Phys.*, Jan., 1954, p. 233. Derivation of a general method for readily approximating numerical values of the amplitudes of the modulation products occurring in the input when a two-frequency input is applied to an arbitrary modulator having a continuous output versus input characteristic.

How to Select Selenium Rectifiers for High Capacity Applications. H. D. James. *Prod. Eng.*, Feb., 1954, p. 192. Circuit utilization of electrical and mechanical characteristics.

RYAN PIONEERS ELECTRONICS

FOR TOMORROW'S AIR WORLD

RYAN is harnessing the tiniest particles of matter—electrons—to guide high speed missiles and aircraft. Through electronics research, Ryan Engineers are developing guidance systems components for missiles and airborne navigational devices for piloted planes. By these electronic means, guidance data is gathered at thousands of times the speed which the human brain can accomplish.

ACHIEVED under Air Force and Navy contracts, these components are telescoped into amazingly small packages to fit into advanced-type aerial vehicles. A typical airborne radar system is so small it can be carried in a handbag. These and other electronic items are outgrowths of Ryan's work in producing the first air-to-air missile—the "Firebird"—several years ago.

RYAN has a unique environment for this research. The same engineers who design electronic systems, man the planes and ground stations for testing them in actual flight and evaluate their test data in the laboratory. This results in complete continuity of development and thorough integration of each problem from laboratory to operational stage.

RYAN

★SPECIALIZED
★INGENIOUS
★VERSATILE

Advanced-type Aircraft and Components
Jet and Rocket Engines and Components
Exhaust Systems for Aircraft
Electronics Equipment
Ceramics for "Hot Parts"
Weapons Systems Design and Management
Aircraft and Power Plant Research
Metallurgical Engineering
Thin-Wall Ducting
Firebee Pilotless Jet Planes

Pioneers in Each ★ Leaders in All

With its 31 years of experience in design and production of aircraft, plus pioneering work in such diverse fields as electronics and metallurgy, Ryan has the gamut of complex skills demanded by the new Weapons Systems Concept.

Because of this versatility, which made possible the development of the electronically controlled "Firebee" pilotless jet plane, Ryan is uniquely qualified to solve today's difficult technical aircraft problems. Already Ryan is at work under recently awarded Weapons System Management contracts which give the company full responsibility for all phases of new aircraft development.

RYAN AERONAUTICAL COMPANY *Factory and Home Offices:* Lindbergh Field, San Diego 12, Calif.
OTHER OFFICES: WASHINGTON, D. C. • DAYTON, OHIO • SEATTLE, WASHINGTON • NEW YORK CITY

#23271
3-WAY SOLENOID OPERATED VALVE
3/8" Line size
Weight 0.9 lb.

ADEL

Pneumatic control valves set new performance standards!

#23314
CHECK VALVE
1/4" & 3/8" Line sizes
Weight 0.13 lb.

#27370
SHUTTLE VALVE
1/4" Line size
Weight .290 lb.

ADEL designed and manufactured to provide the best in control equipment where pneumatic systems are specified. Safe, dependable operation is assured with instantaneous reaction at working pressures up to 3000 psi. These production units have been thoroughly tested and are qualified to meet all applicable specifications.

#27800
4-WAY SOLENOID OPERATED VALVE
3/8" Line size
Weight 1.80 lb.

ADEL produces a complete line of AIRCRAFT HYDRAULIC & PNEUMATIC CONTROL EQUIPMENT; HEATER, ANTI-ICING & FUEL SYSTEM EQUIPMENT; ENGINE ACCESSORIES AND LINE SUPPORTS.

For complete engineering specifications and counsel

Address: ADEL DIVISION, GENERAL METALS CORPORATION
10785 Van Owen Street, Burbank, California

ADEL LEADER IN HYDRAULICS AND PNEUMATICS

MANUFACTURERS OF AIRCRAFT CONTROL EQUIPMENT

DIVISION OF GENERAL METALS CORPORATION • BURBANK, CALIF. • HUNTINGTON, W. VA.

CANADIAN REP. RAILWAY & POWER ENGINEERING CORPORATION, LIMITED

IRE Standards on Circuits: Definitions of Terms in the Field of Linear Varying Parameter and Nonlinear Circuits, 1953. A. G. Jensen, M. W. Baldwin, Jr., W. R. Bennett, and others. *Proc. IRE*, Mar., 1954, p. 554.

Linear Low-Level Rectifiers. H. Scharfman. *Electronics*, Mar., 1954, p. 228. Circuit to rectify audio and subaudio sine waves with a linear dynamic input range between 50 millivolts to 2 volts root mean square, with a corresponding output d.c. range of 0.125–5 volts.

Low-Temperature Electronics. Clayton A. Swenson and Alfred G. Emslie. *Proc. IRE*, Feb., 1954, p. 408. 16 refs. Application of results of research to the reduction of thermal noise; review of the theory of electrical conductance in metals; analysis of the phenomenon of superconductivity as applied.

Magnesium for Electronics and Electrical Applications. *Mag. of Magnesium*, Feb., 1954, p. 1. Evaluation of properties for specialized uses.

Pedestal-Removing Slicer Circuit. Nathan O. Sokal and George M. Nonnemaker. *Electronics*, Mar., 1954, p. 220. USAF-Army-Navy-sponsored research at MIT.

A Quantitative Study of Instrument Approach. Appendix I—The Form of I.L.S. Beam Bends—A Simple Theory. Appendix II—The Mathematical Formulation of Approach Success. J. F. W. Mercer. *J. RAeS*, Feb., 1954, p. 83; Discussion, p. 101; Author's reply, p. 108. Investigations at the Blind Landing Experimental Unit, Ministry of Supply, on the problem of coupling ILS information into an automatic pilot for accurate blind approaches; analysis of basic equipment, stabilization and control factors, and beam distortion; evaluation of approach aids.

A Simple Electronic Multiplier. K. H. Norsworthy. *Electronic Eng.*, Feb., 1954, p. 72. Use of the area under a triangular wave as a squaring device capable of accepting both positive and negative input voltages to obtain d.c. accuracy to within one per cent and for frequencies up to 50 cycles per sec.; application to simulators and servomechanisms.

Split Second Information. William Barratt. *Jet Age*, Winter, 1953–1954, p. 10. Telemetering system for accurate recording of 67 separate items of flight test data per sec.

The Thermal and Electrical Conductivity of Copper at Low Temperatures. G. K. White. *Australian J. Phys.*, Dec., 1953, p. 397. 16 refs.

The Variation of Electrical Conductivity of Air Within Sealed Rooms. L. G. Smith and G. F. Schilling. *J. Atmospheric & Terrestrial Phys.*, Jan., 1954, p. 314. USAF-sponsored theoretical and experimental research at UCLA.

Amplifiers

Cascode Audio Amplifier has Low Noise Level. R. Lee Price. *Electronics*, Mar., 1954, p. 156. Wallman circuit used as input stage of audio amplifier.

D. C. Amplifiers; Methods of Amplifying and Measuring Small Direct Currents and Potentials. II. J. Yarwood and D. H. Le Croissette. *Electronic Eng.*, Feb., 1954, p. 64. 38 refs.

POINT STRENGTH

SMOOTHNESS

BLACKNESS

WEAR

You get balanced performance

from every

TURQUOISE PENCIL

thanks to

100% "Electronic Graphite"

Even the super-soft 6B sharpens perfectly and gives you ample point strength for vigorous black strokes. The whole range of 17 degrees of TURQUOISE is decisively superior in point strength to comparable degrees of other drawing pencils.

Unmatched smoothness in all degrees is the sure result of the extreme particle fineness to which its 100% "Electronic" Graphite is reduced in Eagle's patented, *exclusive* Attrition Mill.

Blackness is appreciably enhanced because thousands more of the super-fine "Electronic" graphite particles are deposited at every stroke on the paper in *denser lines that reproduce to perfection.*

Longer wear is inherent because 100% "Electronic" graphite and super-refined clay binder are combined at white heat into the most closely knit, even-wearing ceramic structure known in pencil leads.

SEND FOR FREE SAMPLE, mentioning this magazine and the grade of pencil you want.

EAGLE PENCIL COMPANY
New York • London
Toronto • Mexiço
Sydney

Design Criteria for Transistor Feedback Amplifiers. S. K. Ghandhi. *Tele-Tech*, Mar., 1954, p. 94. USAF-Army-Navy-supported development of a general theory to overcome shortcomings of elementary design principles; comparison between circuit use of vacuum tubes and junction transistors.

Logarithmic Amplifier With Fast Response. James A. De Shong, Jr. *Electronics*, Mar. 1954, p. 190. Design of a feedback amplifier with high-frequency damping for current measurements in the 10^{-12}–10^{-4} ampere range.

A Pre-Amplifier for Use with Electronic Voltmeters and Oscilloscopes. F. G. Peuscher and J. van Holthoon. *Philips Tech. Rev.*, Dec., 1953, p. 169. Design of type GM 4574, with circuit and operational details.

Wide-Band I. F. Amplifiers; Design Technique Using Negative Feedback. H. S. Jewitt. *Wireless World*, Feb., 1954, p. 86. Applications include radar circuits.

Antennas

Designing Flush Antennas for High-Speed Aircraft. J. V. N. Granger. *Electronics*, Mar., 1954, p. 136. Design characteristics related to operational requirements.

Torque Requirements of a Radar Antenna. Melvin Mark. *Elec. Eng.*, Mar., 1954, p. 262. Results of experimental wind-tunnel tests at MIT for various wind velocities to obtain data for the optimum design of the driving and supporting mechanism.

Communications

Application of Integrator Type Signal Enhancers. Charles A. Strom, Jr., and Joseph A. Fantoni. *Tele-Tech*, Feb., 1954, p. 98. Rome Air Development Center communications investigations to develop the Radio Direction Finding System utilizing a rotating capacitor drum and magnetic storage devices to effect up to 16 db. signal-to-noise ratio improvement.

A Comparison of Amplitude and Angle Modulation for Narrow-Band Communication of Binary-Coded Messages in Fluctuation Noise. G. Franklin Montgomery. *Proc. IRE*, Feb., 1954, p. 447. 16 refs.

Diffusion of Pulsed Currents in Conductors. L. M. Vallese. *J. Appl. Phys.*, Feb., 1954, p. 225. Investigation of the radio communications problem of density distribution and the equivalent depth of penetration of pulsed currents produced by a plane wave incident normally upon a plane conductor.

Radio Communication by Scattering from Meteoric Ionization. Von R. Eshleman and Laurence A. Manning. Proc. IRE, Mar., 1954, p. 530. 18 refs. USAF-ARMY-ONR-supported research at Stanford University.

Prediction of the Likelihood of Interference at Frequencies of 30 to 42 Megacycles in Alaska. T. N. Gautier, Jr., and C. J. Sargent. (*Res. Paper 2468.*) *U.S., NBS J. Res.*, Jan., 1954, p. 21. CAA-sponsored investigation of the MUF-created communications problem.

Construction Techniques

Cast Wave Guides. Samuel Freedman. *Radio & TV News, Radio-Electronic Eng. Sect.*, Feb., 1954, p. 10. Sightmastermold process to precision-mold microwave waveguides and adapters complete with flanges to any dimension or configuration in a single casting operation.

Hermetic Sealing of Electrical Instruments. Robert L. Milamed. *Elec. Mfg.*, Mar., 1954, p. 90. Analysis of fabrication problems of the selection of inert gases on the basis of physical properties and dielectric strength, of case materials and the soldering of the bezel to the glass window, methods of leak testing, and the rate of permeation of gases through solids.

Project Tinkertoy; Modular Design of Electronics and Mechanized Production of Electronics. *U.S., NBS Tech. News Bul.*, Nov., 1953, p. 161. Description of the NavBuAer-sponsored, NBS-developed MDE and MPE systems.

Safety Procedures in Electronic Equipment. Engineering Dept., Aerovox Corp. *Aerovox Res. Worker*, Mar., 1954. 3 pp. Operational and maintenance factors of designing and fabricating electronic equipment for safety.

Simplifying Fabrication of Printed Circuits. E. R. Gamson. *Elec. Mfg.*, Feb., 1954, p. 122. Details of an improved stencil-etch technique utilizing nitric acid.

Standardization of Printed Circuit Materials. W. Hannahs, J. Caffiauz, and N. Stein. *Tele-Tech*, Feb., 1954, p. 68. Design, fabrication, and inspection factors;

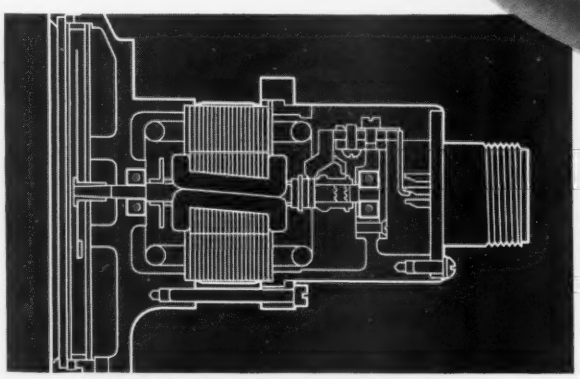
Plan
with
FLEXIBLE
SHAFTS
FLEXIBLE SHAFTS
make for simple grouping of working units and insure quiet, smooth trouble-free operation.
Flexible shafts offer a more economical construction and lower maintenance cost.
Direct alignment in remote control or power transmission around corners is a saving in space and operation.
Write on your letterhead for our Flexible Shaft Manual AER
F.W. STEWART MFG. CORP.
4311-13 RAVENSWOOD AVENUE · CHICAGO 13, ILLINOIS
CIRCLE 555
WEST COAST PLANT: 1638 So. Flower Street, LOS ANGELES 15, CALIFORNIA.

"TOPS" IN LOW-TORQUE APPLICATIONS

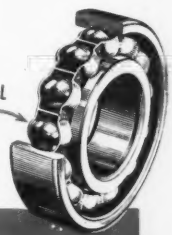
Low-starting-torque bearings are very important in instruments like Kollsman's Manifold Pressure Indicator.

To assure ball bearings with this characteristic, or to meet even more critical requirements, New Departure uses highly sensitive automatic testing equipment capable of measuring torque variations as little as one or two thousandths of a gram centimeter.

When designing instruments it will pay you to talk to your New Departure engineer about your bearing needs.



NOTHING ROLLS LIKE A BALL



NEW DEPARTURE SALES ENGINEERING OFFICES—AT YOUR SERVICE

BRISTOL 269 North Main St. 2-6371
BOSTON 517-A Park Square Bldg. Hancock 6-9867
KANNAPOLIS, N. C. Box 1086 2-3181
NEW YORK 1775 Broadway Circle 6-1540
PHILADELPHIA 850 E. Luzerne St. Garfield 3-4136
SYRACUSE 2360 James St. 73-5195
DETROIT 7-122 General Motors Bldg. Trinity 2-4700
CINCINNATI 2107 Carew Tower Main 5783
CLEVELAND 3113 W. 110th St. Winston 1-5454
INDIANAPOLIS 1357 W. 18th St. Imperial 4680
PITTSBURGH Cathedral Mansions Mayflower 1-8100
CHICAGO 332 S. Mich. Ave. Wabash 2-5875
DAVENPORT 2212 E. 12th St. Davenport 7-7522
KANSAS CITY 1021 E. Linwood Blvd. Valentine 4939
MILWAUKEE 647 W. Virginia St. Broadway 6-9460
ST. LOUIS 3001 Washington Blvd. Franklin 6533
LOS ANGELES 5035 Gifford Ave. Logan 8-2301
BERKELEY 1716 Fourth St. Landscape 6-8750
SEATTLE 5000 First Ave., S. Lander 5920

NEW DEPARTURE
BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT
Plants also in Meriden, Connecticut, and Sandusky, Ohio
In Canada: McKinnon Industries, Ltd., St. Catharines, Ontario

test procedures for foil-to-laminate adhesion.

A Technique of Soldering to Thin Metal Films. Richard B. Belser. *Rev. Sci. Instr.*, Feb., 1954, p. 180. Army Signal Corps-supported experimental investigations; applications.

Thyratron Filament Connections. Morris Brenner and H. G. Schmitt. *Elec. Mfg.*, Mar., 1954, p. 96. Technique using flexible leads with solderless terminals.

VHF Crystal Grinding. E. A. Gerber. *Electronics*, Mar., 1954, p. 161. New lapping and polishing method to improve performance by diminishing unwanted modes of round quartz frequency-control crystals for use in the 20–180 mc. range.

Crystals

Distortion of a Crystal by Point Imperfections. J. D. Eshelby. *J. Appl. Phys.*, Feb., 1954, p. 255. 16 refs. ONR-supported research at the University of Illinois.

The Plastic Deformation of Ammonium Dihydrogen Phosphate. Paul L. Smith and Edward I. Salkovitz. *J. Appl. Phys.*, Feb., 1954, p. 237. X-ray studies of the mechanism of deformation, with some qualitative results concerning the deformation of the ADP crystals.

Dielectrics

Dielectric Constants of Dimethylsilicones. O. B. Young and Charles E. Dickerman. *Ind. & Eng. Chem.*, Feb., 1954, p. 364. Sangamo Electric Co.-sponsored research at Southern Illinois University to determine value of these silicones as impregnating compounds for oil-impregnated capacitors.

Discharge Inception and Extinction in Dielectric Voids. H. C. Hall and R. M. Russek. (*IEE Measurements Sect. Paper 1618.*) *Proc. IEE, Part II*, Feb., 1954, p. 47. 18 refs. Experimental and analytical measurements, including those for various pressures and temperatures.

High-Temperature Resistivity of Polyester Dielectric Film. Leonard E. Amborski and Robert L. Burton. *Elec. Mfg.*, Mar., 1954, p. 124. Investigation of characteristics of Mylar and other dielectrics at temperatures up to 240°C.

Phase Equilibrium Relations in the Systems Lime-Titania and Zirconia-Titania. L. W. Coughanour, R. S. Roth, and V. A. DeProsse. (*Res. Paper 2470.*) *U.S., NBS J. Res.*, Jan., 1954, p. 37. 17 refs. Army Ordnance-sponsored fundamental studies of ceramic dielectrics.

Principles for Temperature Classification of Insulating Materials by Functional Test. K. N. Mathes. *Elec. Eng.*, Mar., 1954, p. 243. 27 refs.

Silicone Dielectric Materials. D. F. Christensen. *Prod. Eng.*, Feb., 1954, p. 187. Evaluation of typical properties; applications.

Silicone Rubber as Electrical Insulation. Alex. E. Javitz. *Elec. Mfg.*, Feb., 1954, p. 126. Developmental review of properties and applications; comparison with other dielectric materials.

Electronic Controls

Error Voltage Detector. M. L. Kuder. *Radio & TV News, Radio-Electronic Eng. Sect.*, Feb., 1954, p. 12. NBS-developed device using crystal diodes in a bridge circuit for sensing the error signal through detection of the difference between two voltages in a servo feedback automatic control system.

Radio Control Directs Air-Sea Rescue Boat. G. V. Schug and S. B. Hall. *Electronics*, Mar., 1954, p. 130. USAF remote-control system in which signals are separated by selective filters in a superregenerative detector circuit receiver in the lifeboat.

Step to Frequency Response Transforms for Linear Servo Systems. II. L. C. Ludbrook. *Electronic Eng.*, Feb., 1954, p. 51. Theoretical and experimental analysis, including checks of the methods on functions.

Transistor Preamplifier Drives Magnetic Servo. Marcel B. Zucchino. *Electronics*, Mar., 1954, p. 168. Adaptation of semiconductor devices to permit matching low-impedance magnetic amplifier outputs to high-impedance servocontrols; analysis of circuit details.

Electronic Tubes

An AC Cathode-Follower Circuit of Very High Input Impedance. James Ross Macdonald. *Rev. Sci. Instr.*, Feb., 1954, p. 144.

Cathode-Ray-Tube Protractor or Synchroscope. Harry Sohon. *Elec. Eng.*, Mar., 1954, p. 220. Operational details of a simple resistor-capacitor circuit permitting a visual indication of phase dif-

An Idea to Reduce Costs... Improve Product Operation
Where intermittent high torque and space economy are important, this specially developed aircraft motor provides distinct advantages.
Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS
• Every Lamb Electric Motor is specially designed for the product or device it is to drive. This means that both mechanical and electrical characteristics are engineered for the exact requirements of the particular application.
Special engineering in Lamb Electric Motors often results in savings in space, weight and cost factor and assures optimum product operation. These are some of the reasons why more and more of America's finest products are being powered with Lamb Electric Motors.
Compactly designed capacitor-type induction motor for wire recorders, electronic tube cooling, and similar services.
The Lamb Electric Company
Kent, Ohio
In Canada: Lamb Electric — Division of Sangamo Company Ltd. — Leaside, Ont.
THEY'RE POWERING AMERICA'S Finest PRODUCTS
Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS

Tomorrow's Planning Today

WHEN YOU LET WEBER *Airgineering*

WORK FOR YOU!

Whether you require today's known needs or are anticipating tomorrow's requirements, our planning and development engineers are ready to serve you.

From design to delivery is Weber's way of completely handling your air-borne equipment project . . . and you save in time and money, too, for we assume complete responsibility for research, design and modern production methods.

Why not take advantage of Weber's "Design-to-Delivery" service? Let us help you on *your* air-borne equipment problems. Call or write today.

WEBER AIRCRAFT CORPORATION

2820 Ontario Street • Burbank, Calif. • CHarleston 8-5543

Subsidiary of Weber Showcase & Fixture Co., Inc.

BUFFET

WA-148

ference between two voltages on a CR-tube screen.

Commutation Factor in Thyratron Circuit Design. D. E. Marshall and C. L. Shackelford. *Electronics*, Mar., 1954, p. 198.

Decimal Counting Tubes. K. Kandiah. *Electronic Eng.*, Feb., 1954, p. 56. Survey of available types with their limiting characteristics; component utilization and circuit details.

The Effect of Organic Vapor on the Secondary Emission of Phosphors. P. H. Dowling and J. R. Sewell. *J. Appl. Phys.*, Feb., 1954, p. 228. Findings of an experimental investigation applicable to cathode-ray tubes.

Electron Tube Performance in Some Typical Military Environments. D. W. Sharp. *Elec. Eng.*, Mar., 1954, p. 233. Aeronautical Radio, Inc. evaluative survey covering air-borne and ground radar, gunfire and missile control systems, IFF, ECM, and other applications.

High-Power Pulser Aids Cathode Studies. Louis A. Marzetta. *Electronics*, Mar., 1954, p. 178. NBS-developed system using parallel 304TH tubes as control diodes to continuously plot emission characteristics on a cathode-ray tube.

A Monoscope Tube for Computer and Other Applications. John Hartmann. *Elec. Eng.*, Mar., 1954, p. 208. Design and circuit details of the K1043 and other tube types as applied.

On the Focusing of High-Current Electron Beams. George R. Brewer. *J. Appl. Phys.*, Feb., 1954, p. 243. 13 refs. Use of multiple magnetic-lens systems for focusing electron beams in traveling-wave tubes to effect savings in weight, space, and power consumption.

Photocathode Uniformity and Resolution of Scintillation Spectrometers. T. F. Godlove and W. G. Wadey. *Rev. Sci. Instr.*, Jan., 1954, p. 1.

A Rapid Flyback Miller (Transitron) Time-Base Circuit. W. Fraser and M. W. Jelffs. *Electronic Eng.*, Feb., 1954, p. 71.

The Thermionic Emission from Thin Films of Barium and Strontium Oxide. J. Woods and D. A. Wright. *Brit. J. Appl. Phys.*, Feb., 1954, p. 74.

Magnetic Devices

Developments in Sintered Magnetic Materials. J. L. Salpeter. *Proc. IRE*, Mar., 1954, p. 514. Review of the basic principles of ferro-magnetism; analysis of the properties of "Ferrocube" and "Magnadur."

Effective Permeability of Cylindrical Iron Cores. Raymond E. Lafferty. *Tele-Tech*, Feb., 1954, p. 84. Design parameters for low hysteresis loss in high-frequency applications; analysis of effect of dimensions, distributed capacitance, and grounding on coil inductance.

Ferrites for Microwave Circuits and Digital Computers. E. Albers-Schoenberg. *J. Appl. Phys.*, Feb., 1954, p. 152. 14 refs. Investigation of ferromagnetic compounds and development of two new classes of magnetic materials.

Ferromagnetic Spinels with Rectangular Hysteresis Loops. I. J. Hegyi. *J. Appl. Phys.*, Feb., 1954, p. 176.

(Magamp) Transductors for Instrumentation of D-C Circuits. W. A. Derr and E. J. Cham. *Westinghouse Engr.*, Mar., 1954, p. 86. Applications include telemetering uses.

Magnetic Amplifiers for Synchronous Motors. Marcel B. Zucchino. *Electronics*, Mar., 1954, p. 133. Downward power conversion from 400 to 60 cycles per sec. by use of self-saturating circuits.

Magnetic-Suspension Ultracentrifuge Circuits. J. W. Beams. *Electronics*, Mar., 1954, p. 152. 13 refs. Development at the University of Virginia of a magnetic support for high-speed rotors as an ideal frictionless bearing to permit speeds up to 50,000,000 r.p.m.; circuit and operational details.

Parallel-Connected Magnetic Amplifiers. S. H. Chow. *J. Appl. Phys.*, Feb., 1954, p. 216.

Penetration of an Electromagnetic Wave into a Ferromagnetic Material. A. Papoulis. *J. Appl. Phys.*, Feb., 1954, p. 169.

Transductors as D-C Instrument Transformers. W. A. Derr and E. J. Cham. *Elec. Mfg.*, Mar., 1954, p. 136. Use of magnetic amplifiers to measure direct current and voltage and for telemetering.

A Transient Analyzer for Magnetic Amplifiers. E. J. Smith. *Elec. Eng.*, Mar., 1954, p. 218. Abridged. Method of determining transient response time.

Transistor Control of Magnetic Amplifiers. G. F. Pittman, Jr. *Radio & TV News, Radio-Electronic Eng. Sect.*, Feb., 1954, p. 13. Results of an experimental investigation into potential applications of transistors as control elements in self-saturating magnetic amplifiers.

Measurements & Testing

An Accurate Voltage Integrator for Magnetic Field Measurement. E. W. Fuller and L. U. Hibbard. *J. Sci. Instr.*, Feb., 1954, p. 36. Design and circuit details of equipment permitting integration of slowly varying voltages or currents with a photographic time record.

Attenuator Design. N. H. Crowhurst. *Electronic Eng.*, Feb., 1954, p. 76. Development of a chart and rapid calculation method.

A Bridge Transistor Tester. David Dorman. *Radio & TV News, Radio-Electronic Eng. Sect.*, Feb., 1954, p. 5. General Radio vacuum-tube bridge Type 561-D adapted to measure point-contact transistor parameters; analysis of circuits.

The Calibration of the Slotted Section for Precision Microwave Measurements. Arthur A. Oliner. *Rev. Sci. Instr.*, Jan., 1954, p. 13. 11 refs. USAF-sponsored research at Polytechnic Institute of Brooklyn.

Curve-Tracer Test Set for Vacuum Tubes. Elmer H. Niehaus. *Tele-Tech*, Feb., 1954, p. 90. Use of an "X-Y" recorder for rapid and accurate plotting of tube characteristics; circuit and calibration details.

The Determination of Torsion Constants for Bulbs and Fillets by Means of an Electrical Potential Analyser. P. J. Palmer. *Aluminum Development Assn. Res. Rep. 22*, Dec., 1953. 24 pp. Design, operational, and circuit details of the analogical apparatus.

Direct Reading of Phase Angles on an Oscilloscope. Carl R. Wischmeyer and Paul E. Pfeiffer. *Rev. Sci. Instr.*, Jan., 1954, p. 41. Measurement method enabling the direct reading of phase-difference angle between voltages applied to horizontal and vertical deflecting plates of a cathode-ray oscilloscope equipped only with a transparent cross-section scale.

Effect of Temperature on Iron Powder Cores. George Katz. *Elec. Mfg.*, Feb., 1954, p. 135. Heat tests on two types of high-frequency powdered iron cores to show changes in "Q" affecting performance under close tolerances.

Electrical Measurements at Centimetre Wavelengths. J. W. Sutherland. *Electronic Eng.*, Feb., 1954, p. 46. Methods of measurement of impedance, attenuation, and power in waveguide systems, including radar and radio communications.

Evaluating Shielded Enclosures. Richard B. Schulz. *Tele-Tech*, Feb., 1954, p. 75. Performance measurement of attenuation of a periodic wave and "insertion loss."

Fast Time Analysis of Intermittent Point-to-Plane Corona in Air. I—The Positive Point Burst Pulse Corona. M. R. Amin. *J. Appl. Phys.*, Feb., 1954, p. 210. 11 refs. ONR-sponsored research at the University of California, Berkeley, Calif. utilizing photomultiplier tubes.

Magnetron Stability Tester. H. S. Bennett and A. A. Kiriloff. *Tele-Tech*, Mar., 1954, p. 96. Design of a radar-type system for analyzing characteristics, including relationships of various factors governing stability.

The Measurement and Calculation of Axial Electromagnetic Forces in Concentric Transformer Windings. M. Waters. (*IEE Supply Sect. Paper 1587.*) *Proc. IEE, Part II*, Feb., 1954, p. 35. Experimental investigation to weigh theoretical treatments.

Measurement of Harmonic Distortion; Self-contained Direct-reading Instrument for Works Testing and Servicing. T. D. Conway. *Wireless World*, Mar., 1954, p. 110. Design development; construction and circuit details.

Measuring Non-Linearity. D. C. Pressey. *Wireless World*, Feb., 1954, p. 60. Technique of error measurement in the analysis of distortion; possible applications including servomechanism testing.

Microwaves Used to Observe Commutator and Slip Ring Surfaces During Operation. A. H. Ryan and S. D. Summers. *Elec. Eng.*, Mar., 1954, p. 251. Measuring and testing technique.

Mismatch Errors in the Measurement of Ultrahigh-Frequency and Microwave Variable Attenuators. R. W. Beatty. (*Res. Paper 2465.*) *U.S., NBS J. Res.*, Jan., 1954, p. 7.

A Multichannel Pulse-Height and Delay Time Recorder. William C. G. Ortel. *Rev. Sci. Instr.*, Feb., 1954, p. 164. ONR-supported development at Yale University of the electronic measuring and recording device; circuit details.

A Precision Electrodynamometer Standard and A.C./D.C. Transfer Instrument. J. W. Whittaker. (*IEE Measurements Sect., Paper 1537.*) *Proc. IEE, Part II*, Feb., 1954, p. 11. 10 refs. Design, construction, and development of an NPL

DOW CORNING

Silicone News

No. 6 of a Series • PUBLISHED BY DOW CORNING CORPORATION, MIDLAND, MICHIGAN

Silicone Compound Protects Aircraft Heater Ignition Unit Against Moisture and Corona

Corona discharge at high altitudes and rusting caused by moisture condensation due to rapid changes in temperature in the new Janitrol aircraft heater ignition units, were reduced to a minimum by the use of Dow Corning 4 Compound.

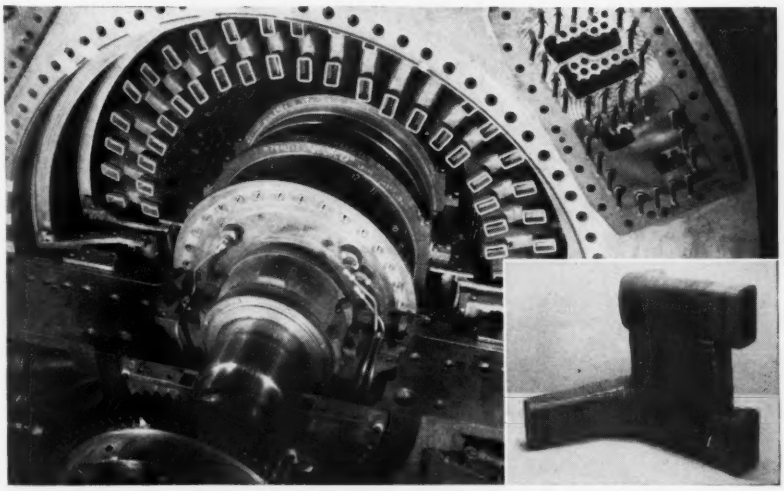
This silicone compound was adopted by engineers of the Aircraft-Automotive Division of Surface Combustion Corporation, Toledo, Ohio, after it was subjected to severe operational testing.

The interior of a stock ignition unit was sprayed with a fine mist of water. The unit, including lead wire and a spark plug with a 5/16 inch gap, was sealed in a bell jar. Air was evacuated with an aspirator. Corona increased as the air pressure dropped until the unit shorted out at a pressure corresponding to an altitude of 25,000 feet.

The unit was then removed from the jar and thoroughly dried. The electrical connections were coated with a thin film of Dow Corning 4 Compound. Again the unit was sprayed with water and sealed under vacuum. Corona discharge was practically eliminated. Even at a pressure equivalent to an altitude of 40,000 feet, there was no sign of failure.

In addition to its usefulness as an auxiliary dielectric, Janitrol engineers report that Dow Corning 4 Compound inhibits corrosion, lubricates ignition cable for easy assembly, and lengthens grommet service life by reducing high temperature oxidation.

No. 49

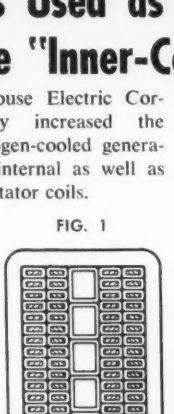


Silastic Caps Used as Dielectric Barriers on High-Voltage "Inner-Cooled" Generator Coils

Engineers at Westinghouse Electric Corporation have greatly increased the capacity of large hydrogen-cooled generators by providing for internal as well as external cooling of the stator coils.

This is done by placing a row of open-ended ventilating tubes inside each stator coil. These metal tubes with conventional insulation are placed between the two groups of transposed conductor strands as shown in the cross-sectional diagram, Figure 1. Differential pressure between one end of the stator winding and the other, forces high density hydrogen through the tubes in close contact with the source of generated heat.

FIG. 1



But the coil ends, where coil-to-coil connections are made, must be left open to permit the hydrogen to pass through the ventilating tubes. Conventional wrap-around surface insulation used since the first motors and generators were invented cannot be used on the connections.

And that's where Silastic* comes in. The vent tubes and coil-to-coil connections are covered with caps molded of Silastic, the Dow Corning silicone rubber. These caps extend far enough beyond the coil ends to form a dielectric barrier that prevents surface creepage and flashover.

The Silastic caps fit solidly over the insulation tapers on the half-coils, and they are taped together with conventional insulating tape. High dielectric strength and voltage endurance, excellent corona resistance, water repellency and the nontracking characteristics of Silastic, assure long service life and complete reliability.

And that is typical of the steadily increasing market for Silastic as a rubbery material with a new order of stability to time and weather and with a new order of usefulness among dielectric materials. This market is in addition to the wide field of usefulness for Silastic as a material that retains its physical and dielectric properties at temperatures far above and far below the limits of any other kind of rubber.

Here are a few of the properties that make Silastic exceedingly useful even where extreme temperatures are not involved. Under identical test conditions, at 14,000 volts, the corona resistance of Silastic cable is in the range of 12,000 hours compared with 30 minutes for organic cable.

The dielectric fatigue curve for Silastic remains relatively flat on long exposure to

*T. M. REG. U. S. PAT. OFF.

(continued pg. 2)

DOW CORNING Silicone News

NEW DEVELOPMENT AND TECHNICAL DATA

For copies of any of the publications reviewed in this column or for data relating to any of the articles printed in this issue of the Dow Corning Silicone News, simply circle the corresponding reference number on the coupon below.

"Silicone Rubber as Electrical Insulation," a reprint of a recent article from ELECTRICAL MANUFACTURING, reviews the properties, advantages and applications of sheet and tape, cable and wire extrusions and other forms of silicone rubber insulating components. *No. 52*

●

Dow Corning Antifoam A, recognized as a most effective defoamer for a wide variety of aqueous and nonaqueous systems, is now available from laboratory supply houses in convenient spray bomb dispensers. Combined with a volatile Freon propellent, Antifoam A Spray quickly and economically controls foams in many batch processes. *No. 53*

●

The Reference Guide to Dow Corning Silicone Products briefly describes the properties and applications of all the most commonly used silicone products. Many manufacturing plants have requested copies for distribution to each of their design and materials engineers. *No. 54*

●

MAY 17-20, 1954 • CHICAGO
BASIC MATERIALS EXPOSITION
THE PRODUCT DEVELOPMENT SHOW

See DOW CORNING SILICONES in action

Visit Booth 329

●

We have recently revised our listing of the manufacturers of silicone (Class H) insulating components. Designers and builders of electric machines and electronic equipment may want to refer to these Sources of Supply. *No. 55*

●

Dow Corning 20 Compound and 20 Emulsion are effectively used as release agents for epoxy, melamine, methacrylate, phenolic, and polyester resin moldings. Their properties and methods of application are described in a recently published data sheet. *No. 56*

At 160-180 C, Life Expectancy of Test Motors Wound with Dow Corning Enameled Wire Equals Class A at 90 C

Accelerated life testing indicates that 7-1/2 hp induction motors insulated with Class H components and wound with wire coated with Dow Corning Wire Enamel have a life expectancy at 160 to 180 C comparable to that of identical Class A motors with organic enameled wire at 90 C.

As reported in a Conference Paper* presented at the 1954 Winter Meeting of the AIEE, test motors were run to destruction by cycling through heat and moisture. By frequent reversal of the direction of rotation, the several Class A motors were subjected to severe vibration and made to operate at test temperatures of 150, 175 and 200 C.

In the same way, motors wound with wire insulated with Dow Corning Wire Enamel were operated at average copper temperatures of 200, 225, 250 and 275 C. After each heat run, the motor stators were exposed to 100% relative humidity for 24 hours. The test motors were then placed directly on the line at no load for a dryout period before starting the next heat run. The failure points and a band showing the life expectancy of these two classes of motors at various operating temperatures are shown in Figure 2.

One of the motors insulated with Class H materials and wound with wire coated with Dow Corning Wire Enamel is still operating after 53 test cycles including 4769 hours at 200 C.

Results to date indicate that design engineers can use wire insulated with Dow Corning Wire Enamel to increase the life of motors and solenoids that now give inadequate service. This new class of magnet wire will also find a large area of usefulness in reducing the size and weight of electric machines and electronic equipment.

Magnet wire insulated with Dow Corning Wire Enamel is now available from most of the leading wire and cable companies. *No. 50

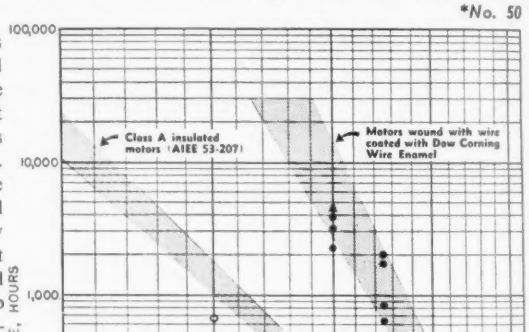


Fig. 2
INSULATION LIFE OF MOTORS
● Failure points of motors wound with wire coated with Dow Corning Wire Enamel.
○ Failure points of Class A insulated motors.
Indicates motors still under test.

SILASTIC CAPS USED *(continued)*

high voltage stress. And dielectric strength and dielectric constant show relatively little change with frequency over a range of 60 cycles to 1 megacycle.

Thermal conductivity is so high that coils can be designed with Silastic insulation to carry the same load and operate at a temperature as much as 30% below that of comparable, resinous insulated coils.

These are some of the properties that make Silastic unique among rubbery materials even at normal operating temperatures. And Silastic is the only kind of rubbery material that is serviceable at temperatures from —100 to above 500 F. *No. 51*

DOW CORNING CORPORATION - Dept. AI-17
Midland, Michigan

Please send me: 48 50 51 52 53 54 55 56

NAME _____

TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE____ STATE_____

DEPARTMENT OF TECHNOLOGY BIBLIOTHEEK/LIBRARY

First in Silicones
DOW CORNING CORPORATION
MIDLAND, MICHIGAN
Atlanta
Chicago
Cleveland
Dallas
Detroit
Los Angeles
New York
Washington, D. C.
(SILVER SPRING, MD.)
Canada: Dow Corning Silicones Ltd., Toronto
England: Midland Silicones Ltd., London
France: St. Gobain, Paris

Manufacturers of
Silicone Fluids
Silicone Abhesives
Silicone Adhesives
Silicone Release Agents
Silicone Compounds
Silicone Greases
Silicone Water Repellents
Silicone Bonding Resins
Silicone Electrical Insulating Resins
Silicone Molding Compounds
Silicone Expansible Resins
Silicone Defoamers
Silastic

(South Africa) combined wattmeter-voltmeter-ammeter-milliammeter and a.c. to d.c. transfer meter for use at 0.5–5 amp. and 25–500 volt ranges and at 50 milliamperes.

Precision Transistor Test Equipment. R. Johnson, D. Humez, and G. Knight, Jr. *Tele-Tech*, Feb., 1954, p. 74. Design details of the "Transtester" for direct and accurate measurements of low-frequency a.c. behavior patterns and d.c. and dynamic characteristics of point contact and junction diodes, "h" parameters of point-contact transistors, and input and output impedances of complete amplifiers and switching circuits.

Resistances in Parallel; Calculating Effective Values on the Slide Rule. Francis Oakes. *Wireless World*, Feb., 1954, p. 95.

A Stroboscopic Frequency Meter. C. W. McLeish and D. H. Rumble. *Proc. IRE*, Mar., 1954, p. 594. System applied to a communications receiver of 3–30 mc. range for direct frequency readings.

Test Cell for Measuring the Dielectric Strength of Elastomeric Materials in Air. Stanley I. Reynolds. *Rev. Sci. Instr.*, Feb., 1954, p. 177.

Transistorized Megohmmeter; Compact Two-range Instrument Using a Transistor E.H.T. Generator. P. B. Helsdon. *Wireless World*, Mar., 1954, p. 121. Design and circuit details.

Use and Maintenance of the A-C VTVM. Jay Dobrin. *Instruments & Automation*, Feb., 1954, p. 288. Applications of vacuum-tube voltmeters to impedance and current measurements.

Networks

Analysis of Hunting Phenomena in Power Systems by Means of Electrical Analogues. D. W. C. Shen and J. S. Packer. (*IEE Supply Sect. Paper 1565.*) *Proc. IEE, Part II*, Feb., 1954, p. 21. 25 refs. Basic theoretical principles applied to network analysis; development of a unit capable of solving steady-state stability problems and of producing directly the system swing curves for transient problems without the necessity for step-by-step computations.

Determination of Equivalent Circuit Parameters for Dissipative Microwave Structures. L. B. Felsen. *Proc. IRE*, Feb., 1954, p. 477. 10 refs. Analysis of basic theory applied to methods developed around "distance invariant" equivalent networks possessing a number of desirable features while permitting simplification in the necessary calculations.

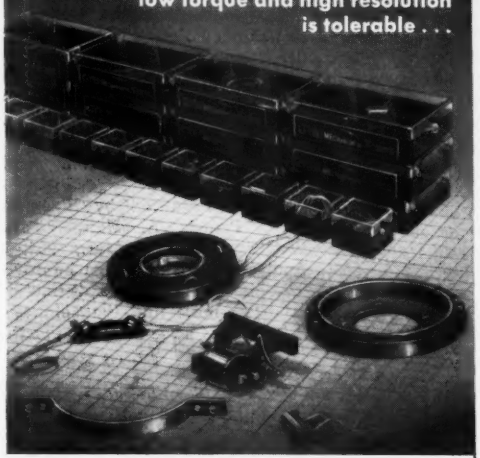
The Direct Method of Filter and Delay Line Synthesis. Marcel J. E. Golay. *Proc. IRE*, Mar., 1954, p. 585. Comparison between the classical and the direct methods of designing passive, nondissipative, linear filters consisting of a network of capacitances, inductances, and transformers.

Radio-Frequency Phase-Difference Networks: A New Approach to Polyphase Selectivity. M. G. Cifuentes and O. G. Villard, Jr. *Proc. IRE*, Mar., 1954, p. 588. 13 refs.

A General RLC Synthesis Procedure. Appendix I—Partial Fraction Expansion of a Positive Real RLC Function. Appendix II—Reduction of Lattices to Unbalanced

SPECIAL POTENTIOMETERS

for Gyroscopes and other applications where only the utmost in low torque and high resolution is tolerable . . .



Noble metal, precision potentiometers for special applications, available in a variety of physical and electrical configurations. Exclusive design and control techniques permit production of potentiometers with a high figure of merit (resolution per unit torque) and extremely low values of noise and contact resistance.

Gyromechanisms' potentiometers are ideal for gyro, computer and other specialized low torque applications, and are presently being supplied to fill the needs of the country's foremost missile programs. Gyromechanisms' engineering service and experience in gyro and instrumentation fields are at your disposal. Pre-production models may be supplied within one month.

WRITE FOR LITERATURE

GYROMECHANISMS, INC.

HALESITE • LONG ISLAND • NEW YORK • HUntington 4-6330

GYROSCOPES • POTENTIOMETERS • ELECTRONIC AND HYDRAULIC DEVICES FOR INSTRUMENTATION AND CONTROL

Now Available!

1954 Aeronautical Engineering Catalog

See Page 180 For Details

AIRSURANCE

Airline Passenger Insurance

Annual Policies from $5,000 to $100,000 at new low rates

No Physical Examination • No Age Limit

EXAMPLE
$25,000.00 for death or dismemberment
$1,000.00 for Hospital and Doctor's bills
$50.00 per week when disabled
PREMIUM $27.50 per year

Policies cover passengers on scheduled airlines WORLD-WIDE

Write or phone your Insurance Agent

U.S. GROUP

Backed by the Combined Assets of

Aetna Casualty & Surety Co.
American Employers' Insurance Co.
American Surety Co. of N. Y.
Century Indemnity Company
The Employers' Liability Assurance Corp., Ltd.
Hartford Accident & Indemnity Co.
Maryland Casualty Co.
Massachusetts Bonding & Insurance Co.
New Amsterdam Casualty Co.
Standard Accident Insurance Co.
Travelers Insurance Co.
United States Casualty Co.
United States Fidelity & Guaranty Co.

UNITED STATES AVIATION UNDERWRITERS
INCORPORATED
80 JOHN ST. • NEW YORK 38, N. Y.
ATLANTA • CHICAGO • DALLAS • KANSAS CITY
LOS ANGELES • SAN FRANCISCO

Networks. Louis Weinberg. *Proc. IRE*, Feb., 1954, p. 427.

A General Tchebycheff Rational Function. Charles B. Sharpe. *Proc. IRE*, Feb., 1954, p. 454.

Normalized Phase and Gain Derivatives as an Aid in Evaluation of FM Distortion. Julius J. Hupert. *Proc. IRE*, Feb., 1954, p. 438. 21 refs. Evaluation of second and third order harmonic distortions generated in a network of known transfer functions when subjected to an undistorted FM input signal.

RC Active Filters. J. G. Linvill. *Proc. IRE*, Mar., 1954, p. 555. Theoretical analysis with experimental tests of operation and design; use of a transistor negative-impedance converter as the active component; network circuit details.

Unbalanced RLC Networks Containing Only One Resistance and One Real Transformer. Louis Weinberg. *Proc. IRE*, Feb., 1954, p. 467. USAF-Army Signal Corps-ONR-supported research at MIT.

Noise & Interference

Current Noise in Thermistor Bolometer Flakes. James J. Brophy. *J Appl. Phys.*, Feb., 1954, p. 222.

Experimental Investigation of Grid Noise. N. Houlding and A. E. Glennie. *Wireless Engr.*, Feb., 1954, p. 35. 17 refs. Analysis including calculation of fully-correlated induced grid noise.

Measuring Noise in Resistors. Milton E. Koch, Jr. *Electronics*, Mar., 1954, p. 181. Development of device featuring an extended low-frequency response with sufficient gain and stability for very-low measurements of total and relative noise in composition resistors; analysis of the nature of noise.

Noise Discriminator for Periodic Signals. Robert L. Conger and Lloyd E. Schilberg. *Rev. Sci. Instr.*, Jan., 1954, p. 52. NOTS-developed circuit design to separate random noise and 60-cps. interference from any periodic signal; theory of operation.

Physical Basis of Thermal Noise. D. A. Bell. *Wireless Engr.*, Feb., 1954, p. 48. 12 refs. Circuit analysis of random noise in terms of thermodynamic equilibrium.

Valve Noise Produced by Electrode Movement. Pamela A. Handley and Peter Welch. *Proc. IRE*, Mar., 1954, p. 565. Analysis aimed at design improvements of noise causes, with a distinction between rattle noise and that of resonances; outline of noise-measuring methods.

Oscillators & Signal Generators

An Amplitude Stabilized Transistor Oscillator. E. R. Kretzmer. *Proc. IRE*, Feb., 1954, p. 391. Design of a circuit capable of supplying 10–100 mw. of power at efficiencies better than 50 per cent, amplitude stability in the order of one per cent, and stable d.c. outputs over a wide range of voltages.

Attenuators for High Frequencies; Basis for a Design Using Standard Components. R. F. Privett. *Wireless World*, Mar., 1954, p. 141. Analysis of the output system of a signal generator.

Audio Oscillator Uses New R-C Design. J. H. Owens. *Electronics*, Mar., 1954, p. 176. Feedback-circuit design of a signal generator for the 11 cycles per sec. to 100 kc. range.

Cathode Follower Oscillator Using RC Networks with a Voltage Step-up. Thomas Roddam. *Wireless World*, Mar., 1954, p. 106.

"Chameleon" Oscillator; Versatile Modified Hartley Circuit Giving High Frequency Stability. Thomas Roddam. *Wireless World*, Feb., 1954, p. 52.

Current-Step Waveform Generator. V. A. Babits, S. R. Spengler, and R. V. Morris. *Electronics*, Mar., 1954, p. 164. Design to provide magnetic pulses of long duration and high intensity for producing sequential light pulses of different colors and to change polarization plane of microwaves in waveform research.

Electronically-Tuned Wide-Range Oscillator. D. D. King and R. L. Konigsberg. *Electronics*, Mar., 1954, p. 184. Design of an experimental Colpitts circuit for operation in the 8.6–46 mc. range utilizing a helical transmission line and crystal diodes.

Gated Time Markers for CRO Display. Philip Steinberg. *Electronics*, Mar., 1954, p. 150. Intensity-modulated dot markers for measuring waveform-time relationships in separate oscilloscope trace without distorting waveform under study.

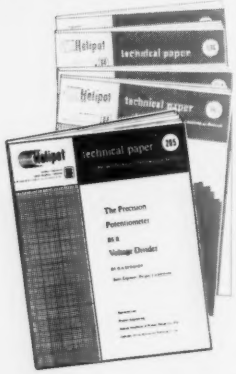
Staircase Generator Counts Pulses. Nathan O. Sokal and Ira L. Resnick. *Electronics*, Mar., 1954, p. 187. USAF-Army-Navy-sponsored MIT development

Helinews FROM HELIPOT TECHNICAL INFORMATION SERVICE

Write today for your FREE copy of this technical paper, reprinted from Product Engineering: Annual Handbook of Product Design for 1954.

The Precision Potentiometer as a Voltage Divider

By H. A. Schmidt
Sales Engineer,
Helipot Corporation



Write for Data File 534

Helipot *first in precision potentiometers*

Helipot Corporation / South Pasadena, California
a division of BECKMAN INSTRUMENTS, INC.

335

Imperial
THE *Finest*
TRACING CLOTH

Imperial is known in drafting rooms all over the world as the traditional quality tracing cloth.

With the background of decades of experience, its makers have pioneered in modern improvements to maintain Imperial as the finest tracing cloth made.

Where's "Charlie"?

The "bird" will find him!

As it rockets along at supersonic speeds—high above the earth—its guidance system directs it unerringly to target "Charlie."

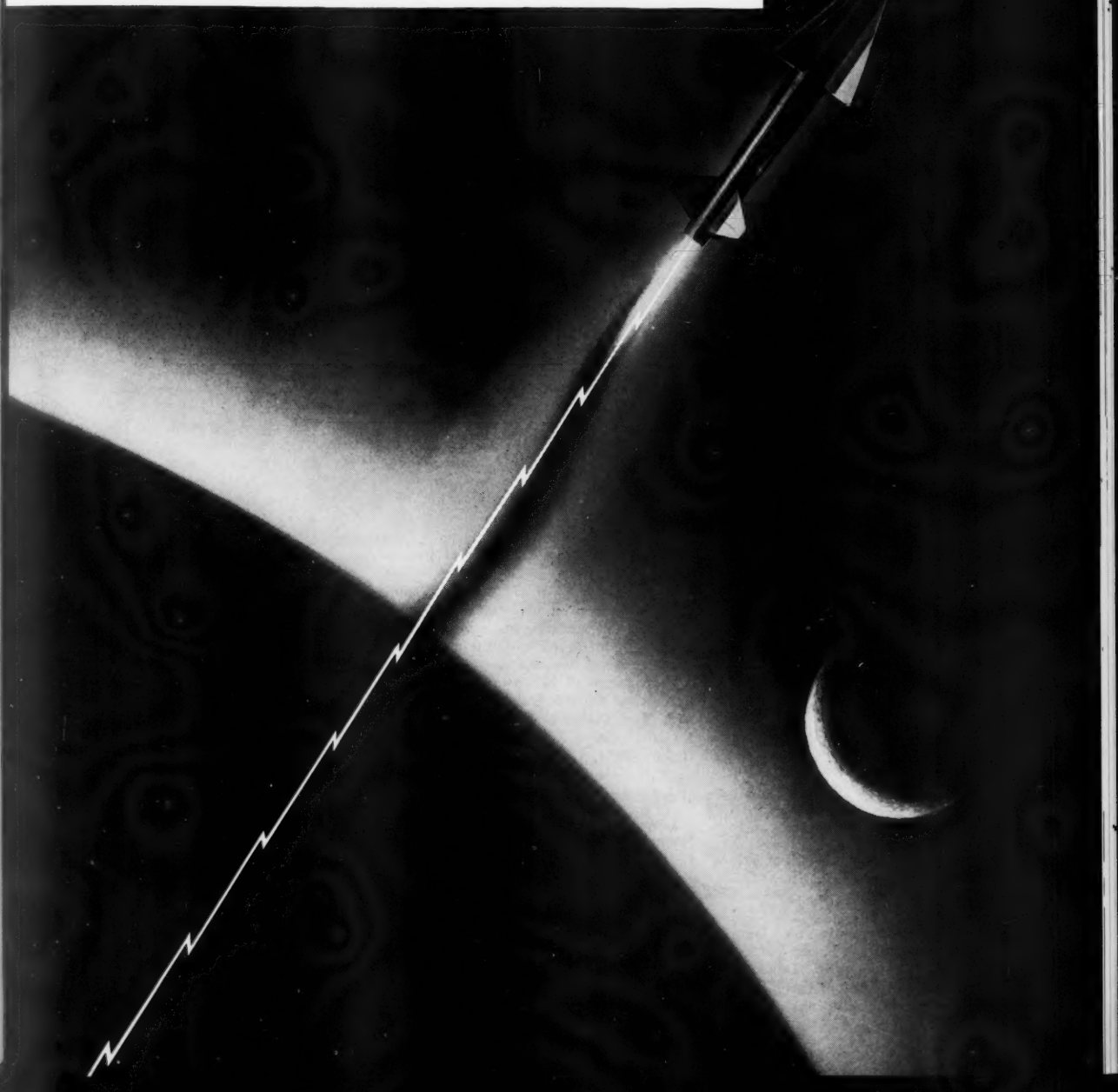
Electronics makes today's accurate missile guidance a reality—and *electronics* is the past, present and future of RCA.

For years, RCA has been working with the Armed Forces on design and engineering of more accurate, more effective missile-guidance systems. The same RCA engineering facilities—from original planning to final production stages—are available for development of complete electronic systems of all kinds. For additional information, write to Government Section, Engineering Products Division, Radio Corporation of America, Camden, N. J.

RCA

RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DIVISION CAMDEN, N.J.



of a simple relay circuit adapted to transfer part of capacitor charge to another capacitor coordinated to the arrival of the input pulse producing one step of the output waveform; design permits counts up to 2,000 pulses per sec. with constant-amplitude steps totaling up to 200 volts.

Subharmonic Crystal Oscillators. Moody O. Thompson, Jr., Carroll E. Tschiegg, and Martin Greenspan. *Rev. Sci. Instr.*, Jan., 1954, p. 8. ONR-supported NBS investigation of potentialities.

A Versatile Electronic Function Generator. Rayko Tomovich. *J. Franklin Inst.*, Feb., 1954, p. 109. Circuit design and construction characteristics and nonlinear operational features, with principles of mathematical applications.

A Waveform Generator. R. J. Harron. *Canada, NAE LR-80*, Oct., 1953. 18 pp. For generating any desired waveform at recurrent frequencies of 2–70 cycles per sec. by utilization of a phototube and a CR tube.

Power Supplies

Design of Transistor Power Amplifiers. S. K. Ghandhi. *Electronics*, Mar., 1954, p. 146. Procedure of choosing optimum circuit and transistor connections to obtain best combination of distortion, available output power, power-supply drain, stage gain, and power supply within given transistor characteristics.

A New D.C. Electronic Voltage-Stabilizing Circuit. R. B. Mackenzie. (*IEE Measurements Sect. Paper 1582.*) *Proc. IEE, Part II*, Feb., 1954, p. 59. Design of circuit capable of adjustment for infinite stabilization ratio and zero output resistance with particular advantages for voltages between 1–15 kv.

Radar

Circular Radar Cuts Rain Clutter. W. D. White. *Electronics*, Mar., 1954, p. 158. An AN/CPS-5 radar system with a modified antenna used for experiments in the MIT Radiation Lab. at 1,300 mc.

A Radar Waveform Test Equipment. V. Narayana Rao. *J. Indian Inst. Sci., Sect. B*, Jan., 1954, p. 29. For the generation of square and pulse waveforms in radar systems.

Semiconductors

Behavior of Germanium-Junction Transistors at Elevated Temperatures and Power-Transistor Design. L. D. Armstrong and D. A. Jenny. *Proc. IRE*, Mar., 1954, p. 527.

Electronic Conduction in Grey Tin. J. T. Kendall. *Philos. Mag.* (*7th Ser.*), Feb., 1954, p. 141. Experimental measurement of conductivity and Hall constant in gray tin alloys containing antimony and gallium over a temperature range of 77–286°K.; comparison with other semiconductors: silicon and germanium.

Germanium, a Secondary Metal of Primary Importance. Robert C. Fite. *Sci. Mo.*, Jan., 1954, p. 15. Properties and applications.

Resistivity Measurements on Germanium for Transistors. L. B. Valdes. *Proc. IRE*, Feb., 1954, p. 420. Development of a laboratory method specifically for use with semiconducting materials.

Semiconducting Intermetallic Compounds. *U.S., NBS Tech. News Bul.*, Nov., 1953, p. 174. Review of the NBS experimental research program.

Transistor Applications. J. S. Schaffner. *G-E Rev.*, Mar., 1954, p. 50. Evaluative survey includes cross sections of semiconductive devices.

The Transistor as a Mixer. Jakob Zawels. *Proc. IRE*, Mar., 1954, p. 542. Analyses of point-contact and junction transistors as mixers, with experimental results for signals up to 400 mc.

Transistor Reliability Studies. R. M. Ryder and W. R. Sittner. *Proc. IRE*, Feb., 1954, p. 414. Survey of mechanisms causing failure in particular types of transistors, with recommendations for improvements.

Transmission Lines

Calculation of the Resonant Properties of Electrical Cavities. Sidney Bertram. *Proc. IRE*, Mar., 1954, p. 579. Results of a USAF-sponsored investigation at Ohio State University applicable to the determination of properties of ridge-type waveguides.

Coupling of Modes of Propagation. J. R. Pierce. *J. Appl. Phys.*, Feb., 1954, p. 179. Analysis for the simple case of coupling between two lossless, unattenuated propagation modes of a linear system.

Electromagnetic Shielding with Transparent Coated Glass. Edward I. Hawthorne. *Proc. IRE*, Mar., 1954, p. 548. 15 refs. USAF-sponsored investigation at the University of Pennsylvania of the transmission of uniform plane waves at normal incidence through a multilayer transparent coated glass structure with thin conductive layers utilizing the transmission line theory for the analysis; applications include use in aircraft windshields for deicing and defogging.

Lightweight Waveguides. P. A. Akin. *Elec. Mfg.*, Mar., 1954, p. 112. Details of two USAF WADC projects to develop new methods of producing lightweight UHF conductors.

Normalized Impedance and Reflection Coefficient; Graphical Representation of their Relationship. P. A. Lindsay. *Wireless Engr.*, Feb., 1954, p. 43.

Power Rating of R-F Coaxial Cables. R. M. Soria and J. G. Krisilas. *Tele-Tech*, Feb., 1954, p. 71. WADC-sponsored experimental investigation on performance capacities and measurement techniques for better evaluation of operational range of temperatures.

Propagation of Microwaves Through a Cylindrical Metallic Guide Filled Coaxially with Two Different Dielectrics. IV. S. K. Chatterjee. *J. Indian Inst. Sci., Sect. B*, Jan., 1954, p. 1.

Wave Propagation

Low-Pass Duplexing System for High-Frequency Pulse Transmitters. William L. Hartsfield and Richard Silberstein. *Tele-Tech*, Feb., 1954, p. 76. NBS-design based on open-wire "TR" systems for oblique-incidence ionospheric propagation studies; circuit details.

Radio Echoes Observed During Aurorae and Geomagnetic Storms Using 35 and 74 mc/s Waves Simultaneously. L. Harang and B. Landmark. *J. Atmospheric & Terrestrial Phys.*, Jan., 1954, p. 322. 13 refs. Wave observations at the Norwegian Defence Research Establishment.

Recurrence Relations for Prolate Spheroidal Wave Functions. Imanuel Marx. *J. Math. & Phys.*, Jan., 1954, p. 269. Investigations into electromagnetic problems at the Willow Run Research Center, University of Michigan.

The Troposphere as a Medium for the Propagation of Radio Waves. II. H. Bremmer. *Philips Tech. Rev.*, Dec., 1953, p. 175. Effects of scattering on radio communications.

Equipment

High Performance Flexible Pipe Assembly Equipment. P. E. W. Chorley. *J. SLAE*, Jan., 1954, p. 15. Research and development, maintenance, applications, and other factors.

The Manufacture of Aircraft Tyres. E. S. Tompkins. *J. SLAE*, Dec., 1953, p. 8. Structural makeup and fabrication processes.

Electric

Calculation of Temperature Rise of Intermittent Duty Motors with an Electronic Thermal Analogue Computer. W. R. Hoffmeyer and E. R. Cunningham. *AIEE Winter Meeting Paper*, Jan., 1954. 13 pp. For high-performance aircraft use.

Capacity Commutator Eliminates Frictional Contacts. Angelo Montani. *Tele-Tech*, Mar., 1954, p. 76. New design to overcome inherent drawbacks of conventional rotary contact commutators; analysis of a sequence of circuit configurations.

A Matter of Balance. R. H. Nettell. *J. SLAE*, Dec., 1953, p. 2. Application to the analysis of electrical systems and equipment.

Wide Speed Range Electrical Drives. Lev A. Trofimov. *Elec. Mfg.*, Mar., 1954, p. 118. Evaluative analysis of various types as to basic drive system, horsepower ratings, and speed range and regulation.

Hydraulic & Pneumatic

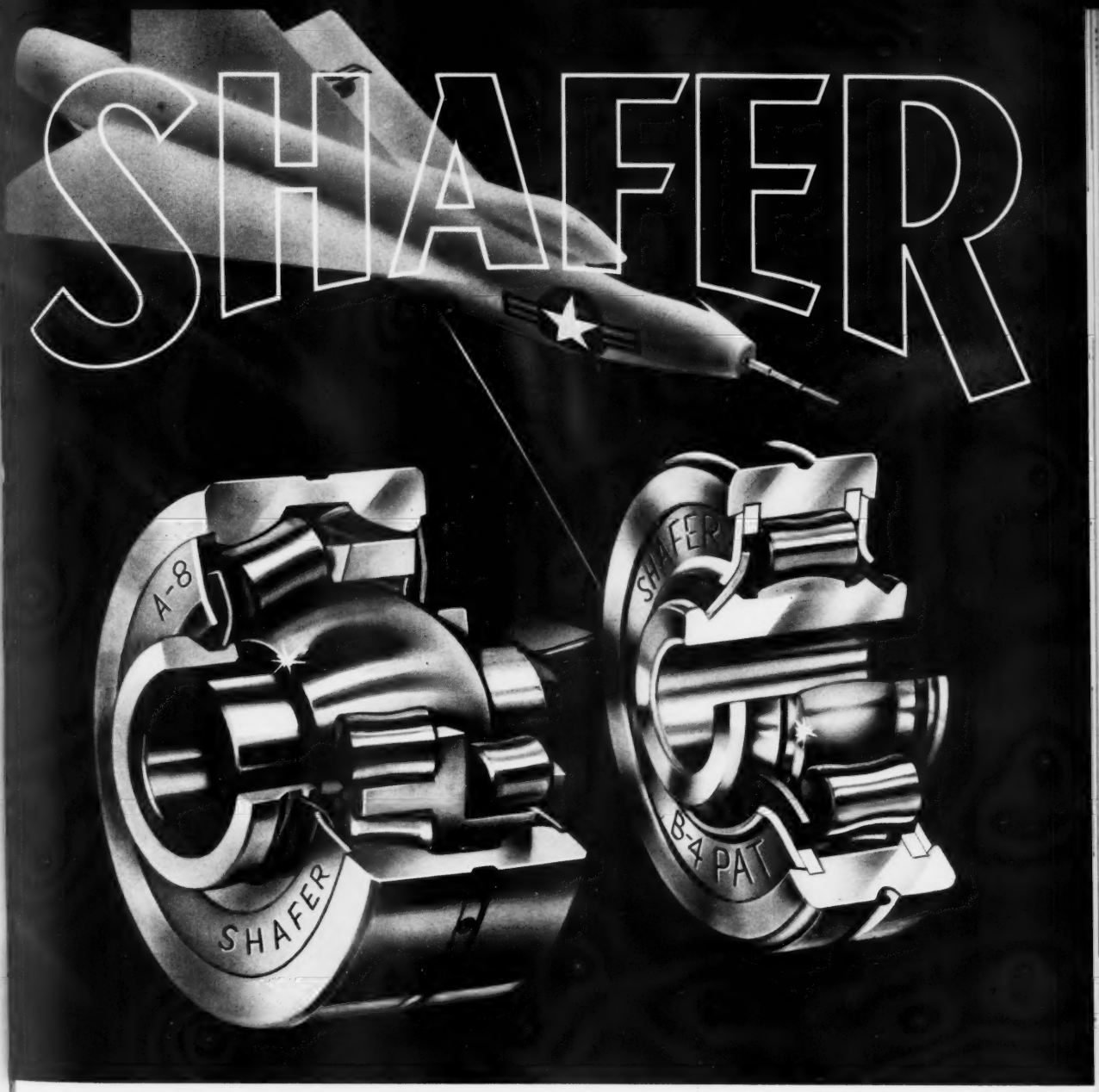
Aircraft Hydraulic Test Rigs. I, II, III. R. T. Sewell. *The Engr.*, Jan. 29, Feb. 5, 12, 1954, pp. 162, 213, 231. Development of apparatus and methods to solve high pressure hydraulic testing problems, with diagrams and charts.

Design of a Hydraulically Operated Aircraft Windshield Wiper. C. R. Sacchini. *Appl. Hydraulics*, Feb., 1954, p. 53, cutaway drawing. As used on the Boeing B-50 airplane, for a hydraulic system of 1,100–3,000 psi. delivery range.

Some Model Experiments on Special Control Valves. I, II. D. Firth and Leslie Young. *The Engr.*, Feb. 5, 12, 1954, pp. 207, 257. Study of design and operational problems, taking into account pressure and flow conditions, with 18 charts and diagrams.

Flight Operating Problems

Skill and the Airman. W. E. Hick. *J. GAPAN*, Dec., 1953, p. 11. The theories of cyclic systems and of information and



CATALOG NUMBER 54

Send for your copy today

Aircraft

ROLLER BEARINGS

SHAFER

DIVISION OF CHAIN BELT COMPANY

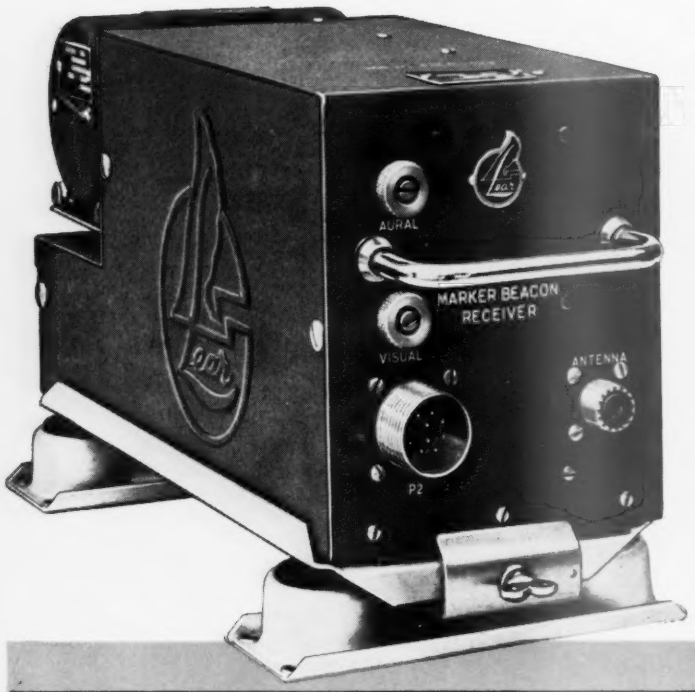
801 Burlington Ave., Downers Grove, Ill.

COMPARE ALL FIVE

—the Lear Marker Beacon Receiver is complete!*

There are several excellent marker beacon receivers on the market today. But as an efficient airplane operator, you will want to select the one that best meets your own requirements. To do this, you'll need *facts*. You will want to compare. Check the table below, and see how the Lear Marker Beacon Receiver *excels* in the number of essential features it offers. Only the Lear Marker Beacon Receiver offers *all* the important features listed below. Send for complete details.

LC-8



LEAR INC.
LEARCAL DIVISION
11916 W. Pico Blvd., Los Angeles 64, Calif.
Exp. Distr.: Lear International Export Corp.
9 East 45th Street, New York, New York

THE LEAR 75 MC. MARKER BEACON RECEIVER. Engineered to meet the highest performance requirements of airline operation, yet compact and light enough in weight to make it suitable for installation in all single- and multi-engine executive aircraft. Complete and dependable aural and visual signal identification, assuring positive "fix" over all ILS, fan, and "z" airway markers.

	LEAR	MAKE "A"	MAKE "B"	MAKE "C"	MAKE "D"
CAA Type Certificated.	✓	✓	✓	✓	✓
Single package construction, providing ease of installation and removal.	✓	✓	✓		
Total weight less than eleven pounds.	✓			✓	✓
Less than ¼ cu. ft. of space required for mounting.	✓				✓
Self-contained power supply — independent of other power sources.	✓	✓	✓	✓	
ARINC tubes — the industry's highest standard — fully utilized.	✓	✓			
Provision for speaker operation as well as headset.	✓				
Three individual indicator lights for outer and middle markers, and airways beacons.	✓	✓	✓	✓	
Press-to-test indicator lamps.	✓	✓		✓	✓
Hi-Lo sensitivity switch, permitting pickup of weak signals or suppression of overly strong or spurious signals.	✓	✓	✓	✓	
Aural and visual sensitivity individually adjustable to pilot preferences and to various installations.	✓	✓	✓		
Cost under $600.00.	✓			✓	✓
***Only the Lear Marker Beacon Receiver combines all these features**	12	8	6	7	5

communication applied to the study of piloting skill.

Fuels & Lubricants

L'Abbassamento del Punto di Congelamento del Tetranitrometano con Mezzi Chimici, e Nota Preliminare sul Sistema: Tetranitrometano-Perossido d'Azoto (On the Lowering of the Freezing Point of Tetranitromethane Using Chemical Means and a Preliminary Note on the System Tetranitromethane–Nitrogen Peroxide). Masaniello Riccardo Corelli. *L'Aerotecnica*, Dec., 1953, p. 391. In Italian.

Explosion and Combustion Properties of Alkylsilanes. I—Temperature-Composition Limits of Explosion for Methyl-, Dimethyl-, Trimethyl-, Tetramethyl-, and Vinylsilane at Atmospheric Pressure. Rose L. Schalla and Glen E. McDonald. *U.S., NACA RM E53L01*, Feb. 5, 1954. 11 pp.

Lubricant for Gas Turbines. *The Aeroplane*, Feb. 5, 1954, p. 163. Analysis of the technical specifications of the ESSO Aviation Turbo Oil 35.

On the Solution of the Reynolds Equation for Slider-Bearing Lubrication. VII—The Nonsteady-State Operation of Tilting-Pad Slider Bearings. F. Osterle, A. Charnes, and E. Saibel. *Trans. ASME*, Feb., 1954, p. 327.

Phase Equilibria in the Carbon Dioxide–Methane System. Harold G. Donnelly and Donald L. Katz. *Ind. & Eng. Chem.*, Mar., 1954, p. 511. 13 refs.

Synthesis and Physical Properties of Several Acetylenic Hydrocarbons. Philip Pomerantz, Abraham Fookson, Thomas W. Mears, Simon Rothberg, and Frank L. Howard. (*Res. Paper 2472.*) *U.S., NBS J. Res.*, Feb., 1954, p. 51. 17 refs. NACA-sponsored research on hydrocarbons as jet-fuel components.

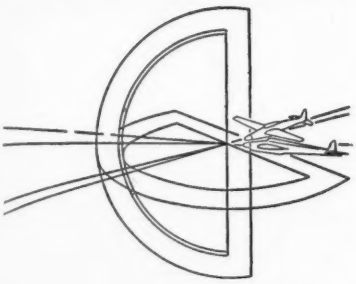
Synthesis and Physical Properties of Several Aliphatic and Alicyclic Hydrocarbons. Philip Pomerantz, Abraham Fookson, Thomas W. Mears, Simon Rothberg, and Frank L. Howard. (*Res. Paper 2473.*) *U.S., NBS J. Res.*, Feb., 1954, p. 59. 15 refs. NACA-sponsored investigation at NBS.

Vapor-Liquid Equilibria at 200 Mm. of Mercury; Binary Systems, Naphthalene–*n*-Tetradecane, Naphthalene–1-Hexadecene, *n*-Tetradecane–1-Hexadecene; Ternary System, Naphthalene–*n*-Tetradecane–1-Hexadecene. S. H. Ward and Matthew Van Winkle. *Ind. & Eng. Chem.*, Feb., 1954, p. 338. 17 refs.

Vapor-Liquid Equilibrium of Naphthalene–*n*-Tetradecane System at Subatmospheric Pressures. Stewart Haynes, Jr., and Matthew Van Winkle. *Ind. & Eng. Chem.*, Feb., 1954, p. 334.

Vapor Pressures and Calculated Heats of Vaporization of Concentrated Nitric Acid Solutions in the Composition Range 71 to 89 Percent Nitric Acid, 7 to 20 Percent Nitrogen Dioxide, 1 to 10 Percent Water, and in The Temperature Range 10° to 60° C. A. B. McKeown and Frank E. Belles. *U.S., NACA RM E53L14*, Feb. 5, 1954. 20 pp.

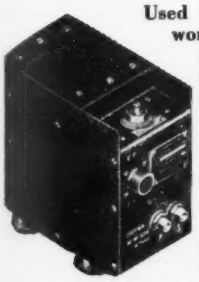
Angle of Attack



Precision Controls by TOPP

the heart of . . .

- Landing Approach Control
- Fuel Economy Control
- Fire Control
- Cruise Control
- Climb Control
- Stall Warning



Used by many of the world's fastest aircraft, the TOPP angle of Attack and Yaw control unit *automatically* increases the accuracy of your fire control system. When used as an integral part of other control systems in which angle of attack and yaw information is necessary, the TOPP instruments perform dependably, instantaneously and with precision.

TOPP engineering facilities solicit your electronic control problems in both aircraft and missile flight operations. Their outstanding record of dependable performance in the field of precision controls deserves your fullest consideration. Wire or write for information.

TOPP

INDUSTRIES, INC.

5255 West 102nd St., Los Angeles 45, California

Giannini

DIGITAL COMMUTATORS

Codes: Binary, Binary-Grey, Binary-Decimal with non-ambiguous outputs

Immediate Delivery from stock on standard models having following characteristics:

- 1,000 counts decimal (300° to 360°)
- 1024 counts—binary, grey (300° to 360°)
- torque—0.5 oz. in ball bearings
- inertia—400 gm. cm²
- micrometer zero adjustment
- automatic alignment—no gears

CUSTOM COMMUTATORS

Commutators can be furnished to fit specific applications by either modification of standard models or wholly new designs. Some variations now available are:

- non-linear coding
- high-count multi-turn units
- ultra low torque models
- miniature size, geared units
- direct decimal coding

G. M. GIANNINI & CO., INC.

LABORATORY APPARATUS DIVISION

PASADENA 1, CALIFORNIA

Offices: New York: Phone Judson 6-7500
Los Angeles: Phone Ryan 1-7152

Giannini

Gliders

Design Study of a Twenty-Five Foot Span Glider. J. A. I. Reid. *Sailplane & Glider*, Jan.-Feb., 1954, p. 10. Analysis of potential performance for hypothetical design, with diagram.

The "LF-109 Pionyr"; A Czech 2-Seat Tandem Glider. R. A. G. Stuart. *Sailplane & Glider*, Jan.-Feb., 1954, p. 7. Design and performance characteristics.

Ice Formation & Prevention

Intermittent Heating of Airfoils for Ice Protection, Utilizing Hot Air. H. H. Hauger, Jr. *Trans. ASME*, Feb., 1954, p. 287. 23 refs. Analog investigation of the effects on the deicing ability of the double-skin design configuration taking into account certain important variables.

A Preliminary Test of an Anti-Freezing Combination Wind Vane and Anemometer on the Summit of Mt. Fuji. M. Sanuki, S. Kimura, and S. Toyama. *Papers in Meteorology & Geophys.*, Apr., 1953, p. 43.

Instruments

The Application of Statistical Methods to Servomechanisms. R. E. Vowels. *Australian J. Appl. Sci.*, Dec., 1953, p. 469. 30 refs.

Designing Emergency Control Into Monitor Circuits. Frank R. Simpson. *Elec. Mfg.*, Feb., 1954, p. 86. "Robot" feedback-controlling devices to translate stored information into action in automatic systems.

Improved Radio Altimeter; Servo Principle Giving Greater Freedom From Noise. A. Bloch, K. E. Buecks, and A. G. Heaton. *Wireless World*, Mar., 1954, p. 138. Instrument for reliable indication up to 5,000 ft. incorporating a continuous-wave transmission at a time-varied frequency between 1,605–1,655 mc. per sec.

Low-Level Altimeter. *U.S., NBS Sum. TR 1832*, Jan., 1954. 8 pp. NBS development for aircraft, using appropriate frequency shifting with modified existing techniques for recognizing short-distance information, to measure altitudes as low as 2 ft.

Measurement of Pressure Transients. Robert T. Eckenrode and Howard A. Kirshner. *Rev. Sci. Instr.*, Jan., 1954, p. 33. 112 refs. Review of basic problems of fluid pressure transient measurement and instrumentation, with an evaluation of mechanical, piezoelectric, condenser, resistance-type, inductance, optical, and other specialized gages.

A Precision Multiple-Mercury-Column Manometer. J. R. Roebuck and H. W. Ibser. *Rev. Sci. Instr.*, Jan., 1954, p. 46. ONR-sponsored experimental studies at the University of Wisconsin to develop the high-pressure measuring instrument.

New Developments in High Temperature Strain Gages. James E. Carpenter. *Res. Trends (Cornell Aero. Lab.)*, Winter, 1954, p. 5.

A New Method of Electrical Recording Suitable for Multi-Channel Working. S. S. Carlisle and J. R. Spencer. *Trans. Soc. Inst. Tech.*, Sept., 1953, p. 105; Discussion, p. 117. Basic design and operational principles; potentialities and applications.

Design and Calibration of Stagnation Temperature Probes for Use at High Supersonic Speeds and Elevated Temperatures. Eva M. Winkler. *J. Appl. Phys.*, Feb., 1954, p. 231. Designed for temperature surveys in the NOL Hypersonic Wind Tunnel No. 4, White Oak, Silver Spring, Md.

Probe Recovery Factor. J. D. Humphreys. *Instruments & Automation*, Feb., 1954, p. 283. Measurement of temperatures of moving fluids at Northrop Aircraft, Inc.

Flow-Measuring Devices

Flight Investigation at Large Angles of Attack of the Static-Pressure Errors of a Service Pitot-Static Tube Having a Modified Orifice Configuration. William Gracey and Elwood F. Scheithauer. *U.S., NACA TN 3159*, Feb., 1954. 25 pp.

The Pitot Method of Measuring Gas Flow Rates in Ducts: An Investigation of Possible Errors. R. Haynes and D. Thomas. *Trans. Soc. Inst. Tech.*, Sept., 1953, p. 121.

Wind Tunnel Tests on Seven Aerovanes. Daniel A. Mazzarella. *Rev. Sci. Instr.*, Jan., 1954, p. 63. 15 refs. NACA-supported investigations at the Brookhaven National Lab., Upton, N. Y., on the usefulness and characteristics of the air-flow measuring device, the Aerovane.

Laws & Regulations

Adequacy of Regulations for VFR/IFR Operations. Wm. P. Person, Moderator, and others. *Skyways*, Mar., 1954, p. 16. Flight Operations Round Table discussion.

Machine Elements

The Bursting Speed of a Rotating Plastic Disc. H. J. Weiss and W. Prager. *J. Aero. Sci.*, Mar., 1954, p. 196. 11 refs. Analysis of the stresses and strains in a fully plastic, rotating, annular disc that has initially uniform thickness and is of a strain-hardening material.

The Dynamics and Lubrication of a Miniature Turbine Rotor on Porous Bushings. George Sines. *Trans. ASME*, Feb., 1954, p. 319. 18 refs.

DC-6 Series Torque Values. *Douglas Serv.*, Jan.-Feb., 1954. 20 pp. Applicable bolt and nut torque loads of the attachment of various DC-6 components, with diagrams, charts, and tables.

Miniature Ball Bearings for Precision Instruments. William L. Timmerman. *Elec. Mfg.*, Feb., 1954, p. 106. Analysis includes load-speed relationships, frictional torque factors, shaft and housing fits, and methods of mounting and lubrication for 12 common types.

Gears & Cams

Constant Torque Power Cams. Carl Thumim. *Prod. Eng.*, Feb., 1954, p. 180. Design procedure; extension of analysis to include friction factors.

Intermittent Spur Gears. Ernest N. Swanson. *Prod. Eng.*, Feb., 1954, p. 175. Design analysis, taking into account interference and binding problems.

Proposal for a Standard Design for General Industrial Coarse-Pitch Cylindrical Worm Gearing. F. G. East. *Trans. ASME*, Feb., 1954, p. 163.

Valve-Gear Fundamentals for the Large-Engine Designer. J. A. Newton and C. H. Allen. *Trans. ASME*, Feb., 1954, p. 137; Discussion, p. 148.

Materials

On Eulerian Co-ordinates in Elastic Wave Propagation. R. E. D. Bishop and J. N. Goodier. *J. Mech. & Phys. Solids*, Jan., 1954, p. 103. Examination of conditions under which an elastic solid "flows through" a disturbance to bring the wave to rest.

On Inoue's Hydrodynamical Analogy for the State of Stress in a Plastic Solid. R. Hill. *J. Mech. & Phys. Solids*, Jan., 1954, p. 110.

Corrosion & Protective Coatings

Action of Polar Organic Inhibitors in Acid Dissolution of Metals. Norman Hackerman and A. C. Makrides. *Ind. & Eng. Chem.*, Mar., 1954, p. 523. 45 refs.

Finishes for Metals; Inorganic and Protective Coatings. I. Robert A. Wason. *Tool Engr.*, Feb., 1954, p. 81. Analytical evaluation of rust preventives, finishes, and types of coatings; selection and other factors.

Stress Corrosion. Mars G. Fontana. *Ind. & Eng. Chem.*, Mar., 1954, p. 99A. Review of the theories of the mechanism of corrosion accelerated by stress.

Thermodynamics of Irreversible Processes Applied to Corrosion. P. A. Johnson and A. L. Babb. *Ind. & Eng. Chem.*, Mar., 1954, p. 518. 11 refs.

Vapor Phase Corrosion Inhibitors. I. D. G. Berwick and B. H. Levelton. *Eng. J.*, Feb., 1954, p. 128. 15 refs. Evaluation of principal types; applications.

Metals & Alloys

Calculations and Measurements on Wedge-Indentation. J. Grunzweig, I. M. Longman, and N. J. Petch. *J. Mech. & Phys. Solids*, Jan., 1954, p. 81. Calculation based on the Hill-Lee-Tupper theory of the penetration, contact pressure, and slip-line field dimensions in plastic indentation by a rough wedge.

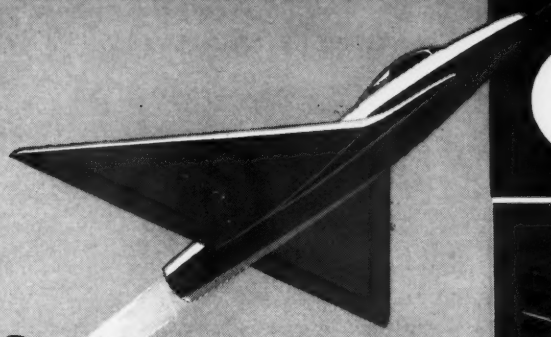
A Dictionary of Metallurgy. XXIV—La-Li. A. D. Merriman and J. S. Bowden. *Metal Treatment*, Feb., 1954, p. 83.

Dynamic Properties of Nodular Cast Iron. II—Size Effect. Harry Majors, Jr. *Trans. ASME*, Feb., 1954, p. 205.

Electrolytic Preparation of Molybdenum. *U.S., NBS Sum. TR 1848*, Jan., 1954. 5 pp. NBS process development for high-temperature applications.

Jet Metals. William P. Brotherton. *Aero Dig.*, Feb., 1954, p. 40. Developmental analysis of new high-temperature alloys relating properties to requirements.

An Investigation on the Isotherma Transformation of an Aluminium Bronze. E. G. Ramachandran and A. Subramanya Iyer. *J. Indian Inst. Sci., Sect. B.*, Jan., 1954, p. 14.



Leadership in fuel metering...

FOR JET, RAMJET AND TURBO-PROP ENGINES

Since the first jets of World War II, Bendix Products Division at South Bend has served the aircraft industry in developing and manufacturing fuel metering systems for jet engines. Today Bendix offers unmatched know-how and facilities both in electronic and hydro-mechanical principles for these important components of jets, ram-jets and turbo-prop engines.

RESEARCH • A staff devoted exclusively to seeking new and better fuel metering techniques — preparing today for the requirements of tomorrow.

ENGINEERING • An organization that is experienced in applying both *electronic* and *hydro-mechanical* principles. Successful creators of lightweight, serviceable equipment to meet the demands of each new advance in engine design.

MANUFACTURING • Two modern and geographically separate manufacturing divisions. Each capable of building to the most exacting test standards — high quality at reasonable cost.

SERVICE • A world-wide service organization that follows through to see that engine operators obtain full benefit from the quality built into the equipment.

EXPERIENCE • A background of more than thirty years of leadership in designing and building fuel metering systems for both reciprocating and jet engines.

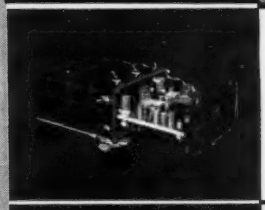
For Your Fuel Metering Requirements Depend Upon Bendix:

• Hydro-mechanical fuel controls • After burner controls • Fuel supply pumps • Spray nozzles
• Electronic fuel controls • Turbo-prop controls • Flow dividers • Ramjet controls

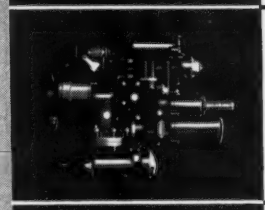
BENDIX PRODUCTS DIVISION SOUTH BEND INDIANA

Bendix AVIATION CORPORATION

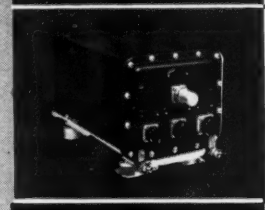
electronic



ELECTRONIC CONTROL Senses engine speeds, gas temperatures and other control factors — then signals fuel requirements to the fuel metering unit.

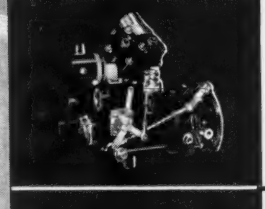


FUEL METERING UNIT Electrically controlled, this unit meters fuel to the engine in accord with signals from the electronic control.

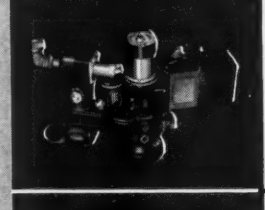


ELECTRONIC AMPLIFIER Maintains a scheduled exhaust turbine temperature by controlling the nozzle area.

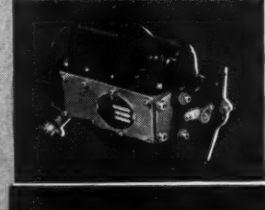
hydro-mechanical



MAIN FUEL CONTROL The control illustrated includes a governor which holds the engine at a selected speed regardless of altitude.



AFTERBURNER FUEL CONTROL Graduates the afterburner thrust by selecting fuel flow in various proportions to mass air flow through the engine.



NOZZLE CONTROL A hydro-mechanical servo control unit which actuates the variable exhaust nozzle mechanism of jet engine.

Bendix Products Division

ELECTRONIC AND HYDRO-MECHANICAL CONTRO

Export Sales: Bendix International Division
205 East 42nd St., New York 17, N. Y.

OPPORTUNITIES FOR ENGINEERS in Electronics, Mechanics and Hydraulics — This division of Bendix is among the world leaders in developing and manufacturing a wide variety of products currently in use by commercial as well as military aviation. Investigate your opportunities with Bendix. Write to Administrative Engineering, Bendix Products Division, Bendix Aviation Corporation, South Bend, Ind.

RCA OPENS NEW HORIZONS in AVIATION ELECTRONICS!

ADVANCE THE SCIENCE OF

FIRE CONTROL • PRECISION NAVIGATION COMMUNICATIONS

You'll find challenge in: Systems, Analysis, Development or Design Engineering

And You Can Specialize In: Radar • Analog Computers • Digital Computers • Servo-Mechanisms • Shock & Vibration • Circuitry • Heat Transfer • Remote Controls • Sub-Miniaturization • Automatic Flight • Transistorization • Design for Automation

You Should Have: Four or more years' professional experience and your degree in electrical or mechanical engineering, or physics

You'll find unlimited opportunities for professional advancement in RCA's broadened aviation electronics program! Suburban or country living nearby. Relocation assistance available.

And at RCA, you'll move ahead through *learning* as well as *doing* . . . for RCA encourages you to take engineering *graduate* study with company-paid tuition. You'll also enjoy professional status . . . recognition for accomplishment . . . unexcelled facilities . . . *many* company-paid benefits.

Your RCA career can start now! Begin by sending a resume of your education and experience to: **Mr. John R. Weld, Employment Manager**
Dept. B-449E, Radio Corporation of America
Camden 2, New Jersey

RADIO CORPORATION OF AMERICA
Tmks. ®

Mathematics

"Monte Carlo" Methods for the Iteration of Linear Operators. J. H. Curtiss. *J. Math. & Phys.*, Jan., 1954, p. 209. 17 refs.

A Note on Sets of Matrices Simultaneously Reducible to the Triangular Skeleton. J. C. Eaves. *J. Math. & Phys.*, Jan., 1954, p. 302.

On Richardson's Method for Solving Linear Systems with Positive Definite Matrices. David Young. *J. Math. & Phys.*, Jan., 1954, p. 243. 15 refs. Army Ordnance-sponsored research at the University of Maryland and at the Ballistic Research Labs., Aberdeen Proving Ground, Md.

Solution of Nonlinear Differential Equations by the Reversion Method through the First Thirteen Terms. George I. Cohn and Bernard Saltzberg. *J. Appl. Phys.*, Feb., 1954, p. 252.

Meteorology

Dependence of the Forms of Natural Snow Crystals on Meteorological Conditions. L. W. Gold and B. A. Power. *J. Meteorology*, Feb., 1954, p. 35. McGill University studies.

Errors Inherent in the Radar Measurement of Rainfall at Attenuating Wavelengths. Walter Hitschfeld and Jack Bordan. *J. Meteorology*, Feb., 1954, p. 58. USAF-sponsored research at McGill University.

Experiments on the Amount of Splash from the Wind Shield of a Rain Gauge. M. Sanuki and N. Tsuda. *Papers in Meteorology & Geophys.*, Apr., 1953, p. 35. Extension of water tank and wind tunnel tests to determine means of preventing the splash.

500-Millibar Studies at Project AROWA. F. A. Berry, W. H. Haggard, and Paul M. Wolff. *Bul. AMS*, Dec., 1953, p. 444. Preliminary results of investigations of applied research problems covering 1946–1951 at the Naval Air Station, Norfolk, Va.

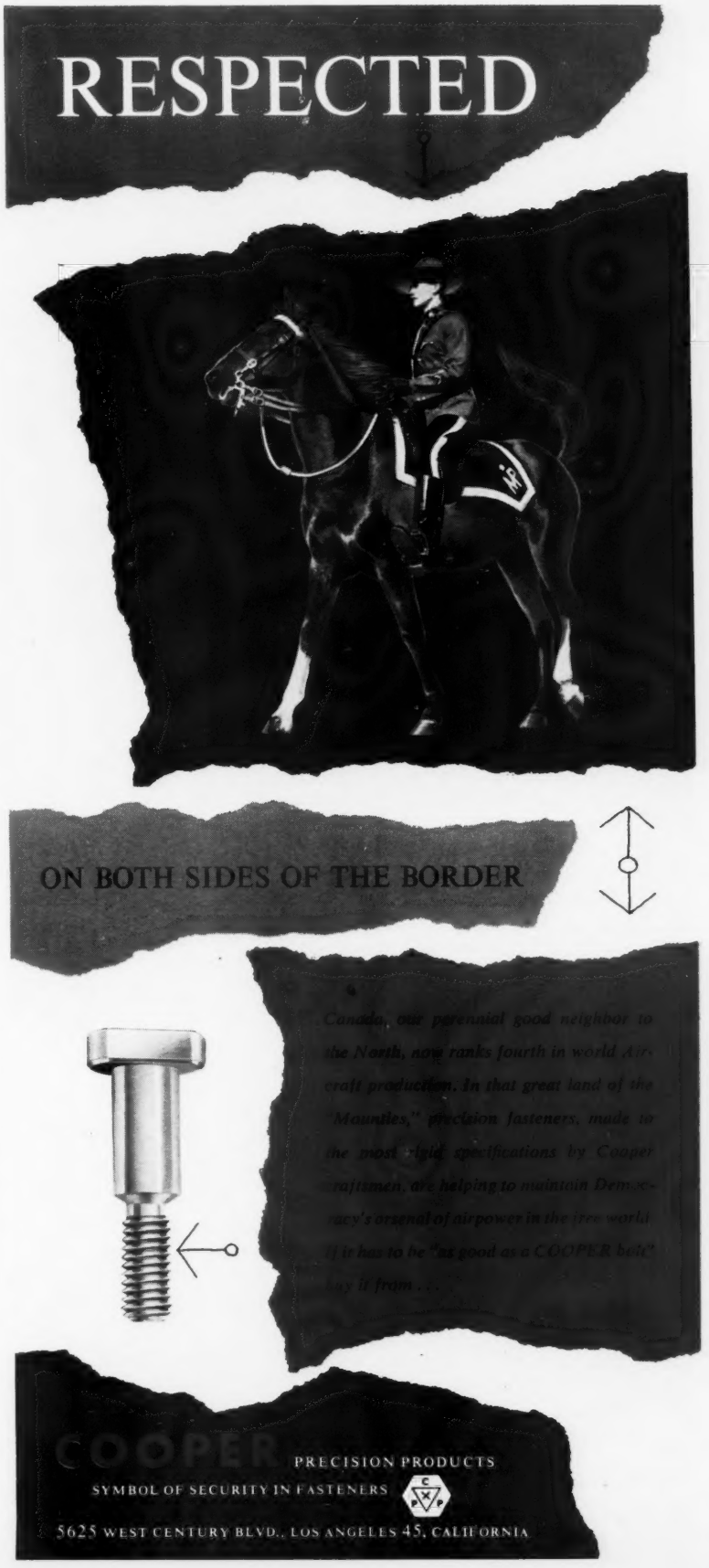
Flight Characteristics of Expansible Balloons. J. F. Darby, V. D. Hopper, Jean E. Laby, and A. R. W. Wilson. *Australian J. Phys.*, Dec., 1953, p. 471. 10 refs. Cosmic ray research in the upper atmosphere at Melbourne University.

Planetary Waves in the Atmosphere. Isadore Silberman. *J. Meteorology*, Feb., 1954, p. 27. 18 refs. USAF-sponsored research at NYU.

Radar Evidence of a Generating Level for Snow. K. L. S. Gunn, M. P. Langleben, A. S. Dennis, and B. A. Power. *J. Meteorology*, Feb., 1954, p. 20. USAF-sponsored studies at McGill University.

Rocket Measurements of Upper Atmosphere Ambient Temperature and Pressure in the 30- to 75-Kilometer Region. H. S. Sicinski, N. W. Spencer, and W. G. Dow. *J. Appl. Phys.*, Feb., 1954, p. 161. 15 refs. USAF-sponsored investigation at the University of Michigan.

Rockets and the Upper Atmosphere. Homer E. Newell, Jr. *Sci. Mo.*, Jan., 1954, p. 30. 17 refs. Survey of high-altitude research.


RESPECTED
ON BOTH SIDES OF THE BORDER
Canada, our perennial good neighbor to the North, now ranks fourth in world Aircraft production. In that great land of the "Mounties," precision fasteners, made to the most rigid specifications by Cooper craftsmen, are helping to maintain Democracy's arsenal of airpower in the free world. If it has to be "as good as a COOPER bolt" buy it from . . .
COOPER
PRECISION PRODUCTS
SYMBOL OF SECURITY IN FASTENERS
5625 WEST CENTURY BLVD., LOS ANGELES 45, CALIFORNIA

Today we stand on the threshold of the second half-century of Powered Flight. With the experience gained since the Wright Brothers, the aircraft industry looks forward to making even greater contributions to man's mastery of the air.

Bell Aircraft Corporation, one of the recognized leaders, needs young, imaginative, capable engineers to play an important part in this period of aeronautical advancement.

LOOK TO YOUR FUTURE WITH BELL

Our engineers aren't limiting their vision to next month or next year. They're thinking, designing, researching and planning decades...yes, even generations... ahead.

Supersonic aircraft...the Bell X-1A, *fastest in the world*...guided missiles, electronics, rocket engines and helicopters are some of the fields in which they are engaged. It is important to remember, too, that almost every branch of science is represented in our fast growing engineering division.

Write TODAY for more information about our liberal retirement, hospitalization and educational benefits for engineers...AND YOUR FUTURE WITH BELL.

Director, Engineering Personnel
BELL Aircraft CORP.
P. O. BOX 1 • BUFFALO 5, N. Y.
FORT WORTH, TEXAS and NIAGARA FALLS, N. Y. with facilities at Edwards Air Force Base, Calif. Holloman Air Research Development Center, New Mexico.

Some Climatological Problems Associated with Assignment of Engineering Design Criteria. Woodrow C. Jacobs and William C. Spreen. *Bul. AMS*, Dec., 1953, p. 462.

Some Problems of Aviation Weather Forecasting. P. J. Meade. *Aeronautics*, Mar., 1954, p. 65. Includes analyses of upper-air winds, jet streams, clear-air turbulence, procedures for accurate landing, and other factors.

Military Aviation

Outlook for Air Power. L. C. Craigie. *Ordnance*, Mar.-Apr., 1954, p. 742. Development of a "weapons system" and other considerations.

Missiles

Boost-Glide Rocket. A. M. Jackes. *Aero Dig.*, Feb., 1954, p. 34. Theoretical extension of a method of arriving at the range of rocket aircraft.

General Equations of Motion of a Rigid Missile. T. Chang. *Cornell Aero Lab. MR CAL-43*, July 15, 1952. 14 pp. Derivation of the equations for the general case of all six degrees of freedom.

"Missile Off—On Money!" Paul R. Heinmiller. *G-E Rev.*, Mar., 1954, p. 8. A 14-page survey of guided-missiles research at White Sands Proving Ground, Las Cruces, N.M.

They Call It "The Thing." L. W. J. Newman. *Jet Age*, Winter, 1953–1954, p. 1. Evaluation of missile design, performance, propulsion, guidance, control, and potentiality factors.

Use of Aerodynamic Heating to Provide Thrust by Vaporization of Surface Coolants. W. E. Moeckel. *U.S., NACA TN 3140*, Feb., 1954. 37 pp. 10 refs. Potential application to missile design.

Navigation

Periscopic Sextants for the Air Navigator. *The Aeroplane*, Jan. 22, 1954, p. 100; cutaway drawing by W. R. Hobbs. Design development and functions of the Kelvin and Hughes Model MK.1A.

Noise Reduction

Improved Absorption Silencing for Ventilating and Exhaust Systems. O. Gerber. (*Konstruktion*, Nov., 1953, p. 363.) *Engr. Dig.*, Feb., 1954, p. 61. Methods and applications for noise reduction up to 380 db. per m., with charts and diagrams.

Photography

An Equation for Approximating the Vertical Exaggeration Ratio of a Stereoscopic View. E. R. Goodale. *Photogrammetric Eng.*, Sept., 1953, p. 607.

High-Speed Turbine-Driven Rotating Mirrors. Willard E. Buck. *Rev. Sci. Instr.*, Feb., 1954, p. 115. Development of rotating mirrors as the basic element in the highest-speed cameras of the framing and sweeping image types; design of a camera for recording high-speed phe-

nomenon at the rate of 3,500,000 frames per sec.

Image-Converter Camera for Studies of Explosive Phenomena. F. C. Gibson, M. L. Bowser, C. W. Ramaley, and F. H. Scott. *Rev. Sci. Instr.*, Feb., 1954, p. 173. ONR- Army Ordnance-supported development to permit 10^{-7}-second exposures.

Simplified Graphs and Tables for Use with Optical Rectifiers. Edwin A. Roth. *Photogrammetric Eng.*, Sept., 1953, p. 630. Analytical procedures applicable to the Bausch and Lomb autofocus and the Fairchild RP-II rectifiers.

Some Factors Causing Vertical Exaggeration and Slope Distortion on Aerial Photographs. Victor C. Miller. *Photogrammetric Eng.*, Sept., 1953, p. 592.

Physics

Ultra-High Vacuum. II—Limiting Factors on the Attainment of Very Low Pressures. D. Alpert and R. S. Buritz. *J. Appl. Phys.*, Feb., 1954, p. 202. 16 refs.

Power Plants

Reheat Turbojet or Ramjet Propulsion? Eugen Sänger. *Interavia*, No. 2, 1954, p. 111. Comparative and evaluative analysis of interceptor power-plant developmental problems.

Jet & Turbine

American Gas Turbines in 1953. Continental Gas Turbines in 1953. Range of Small Gas Turbines. *The Engr.*, Feb. 12, 19, 1954, pp. 249, 272, 285, charts, diags., cutaway drawing. Developmental survey including factors of turbine design, construction, and operation.

The Case for the Turboprop. C. Branson Smith. *Aero Dig.*, Feb., 1954, p. 21. (Also in *Western Av.*, Feb., 1954, p. 6.) Evaluative analysis of the relative advantages of the turboprop engine over the turbojet.

Correlation of Isothermal Contours Formed by Penetration of Jet of Liquid Ammonia Directed Normal to an Air Stream. David B. Fenn. *U.S., NACA RM E53J08*, Feb. 3, 1954. 38 pp. Findings of investigation applicable as criteria for the design of thrust-augmentation systems utilizing liquid ammonia to cool the air at the compressor inlet.

The Determination of Temperature Distribution in Gas Turbine Rotor Bodies and Cylinders by the Electrolytic Tank Method. H. Baumann. *Brown Boveri Rev.*, May-June, 1953, p. 189.

The Elastic-Fluid Centripetal Turbine for High Specific Outputs. Rudolph Birmann. *Trans. ASME*, Feb., 1954, p. 173; Discussion, p. 185. Theoretical and experimental analysis of potentialities of the centripetal turbine; comparison with axial-flow types covering design, performance, and other factors.

General Electric J47. R. E. Small. *Aero Dig.*, Feb., 1954, p. 28, cutaway drawing. Detailed analysis of design and operational characteristics.

Small Turbines—Heart of Accessory Power Systems. L. W. Biwer and R. L. McManus. *Aero Dig.*, Feb., 1954, p. 52,

To **1954** *Aerodynamicists:*

Where will you be in **1964?**

● Will you have shifted from job to job, seeking the "right spot" and never finding it? Or will you have moved ahead steadily at one company, gaining recognition and promotion through achievement?

● The answer to those questions depends on more than ability and ambition. It also depends on opportunity . . . opportunity to show what you can do . . . opportunity to make hard work and accomplishment pay off in promotion . . . the kind of opportunity you get at Lockheed, working on such diversified projects as huge luxury airliners, jet transports, fighters, bombers, trainers, vertical rising aircraft, nuclear energy and other classified activities.

● There are other important yardsticks with which to measure a job: salary, extra employee benefits, living conditions. All standards that tell you *today's* job is a good one; all excellent at Lockheed.

● But it is opportunity that makes a Lockheed job a position of the future—a position that in 1964 will enable you to look back on a record of achievement you earned *because you had the opportunity.*

Lockheed *invites inquiries from Aerodynamicists who seek opportunity for achievement. Coupon below is for your convenience.*

Lockheed

AIRCRAFT CORPORATION

BURBANK • CALIFORNIA

Mr. E. W. Des Lauriers, Dept. AER-A-5
Lockheed Aircraft Corporation
1708 Empire Avenue, Burbank, California

Dear Sir:
Please send me your Lockheed brochure describing life and work at Lockheed in Southern California.

Name

Field of engineering

Street Address

City and State

DEPARTMENT OF TECHNOLOGY
SEALE PUBLIC LIBRARY

Every man has his own ceiling. What's yours? If you're going up—and far... if you are willing to match your ability against the toughest engineering challenge... if your sights are high, and you'll stake the future on your belief in *you*... then there may be a place for you here.

No plush inducements or resort accommodations. Just the chance to join one of the greatest creative engineering organizations in the whole new world of spaceborne systems development.

If it's only a job you want, the woods are full of them. But if you are one of the few who are destined to go far in this industry, you'd be wise to take an engineer's-eye view of the mindpower and the facilities you'll be working with.

Write to J. M. Hollyday, Box 988.

Martin AIRCRAFT THE GLENN L. MARTIN COMPANY BALTIMORE · MARYLAND

cutaway drawing. Descriptive evaluation of operational adaptability.

Reciprocating

The Effect of Fuel Sulfur and Jacket Temperature on Piston Ring Wear as Determined by Radioactive Tracer. M. Popovich and R. W. Peterson. *Ore. State Coll. Eng. Exp. Sta. Bul. 33*, July, 1953. 29 pp. 42 refs. Investigation includes: theoretical analysis of ring and cylinder wear including friction, abrasion, corrosion, and scuffing; wear test methods; and details of apparatus and procedures.

Serck Radial Flow Oil Coolers. Serck Radiators Ltd. *J. SLAE*, Dec., 1953, p. 11. Construction, maintenance, and operational details.

Rocket

L'Endoreazione e le sue Attuali Possibilità (On the Present Possibilities of Rocket Motors). Vittorio Sivori. *L'Aerotecnica*, Oct., 1953, p. 367. In Italian. Review of the principles of operation and basic characteristics of chemical rocket engines; analysis of problems related to the use of solid and liquid propellants.

Production

Laminated Glass Fiber Plastic Tooling Cuts Lead Time Up To 50 Per Cent. Thomas Mac New. *Auto. Ind.*, Mar. 1, 1954, p. 46. Goodyear Aircraft Corporation's fabrication experience on airplane components.

Vickers-Armstrongs Viscount. I—Problems of Civil-Aircraft Manufacture; Viscount Development; Production Capacity. *Aircraft Prod.*, Mar., 1954, p. 88.

Metalworking

Carbon-Dioxide Cooling; Developments in its Application as a Coolant in Machining Operations; Methods of Delivery to the Tool-Point; Storage. *Aircraft Prod.*, Mar., 1954, p. 96.

Discontinuous Chip Formation. N. H. Cook, Iain Finnie, and M. C. Shaw. *Trans. ASME*, Feb., 1954, p. 153. Analysis of the role of deformation and fracture in the metal-cutting process.

The Friction Terms in Metal Cutting. W. C. Leone and Edward Saibel. *Trans. ASME*, Feb., 1954, p. 195. 14 refs.

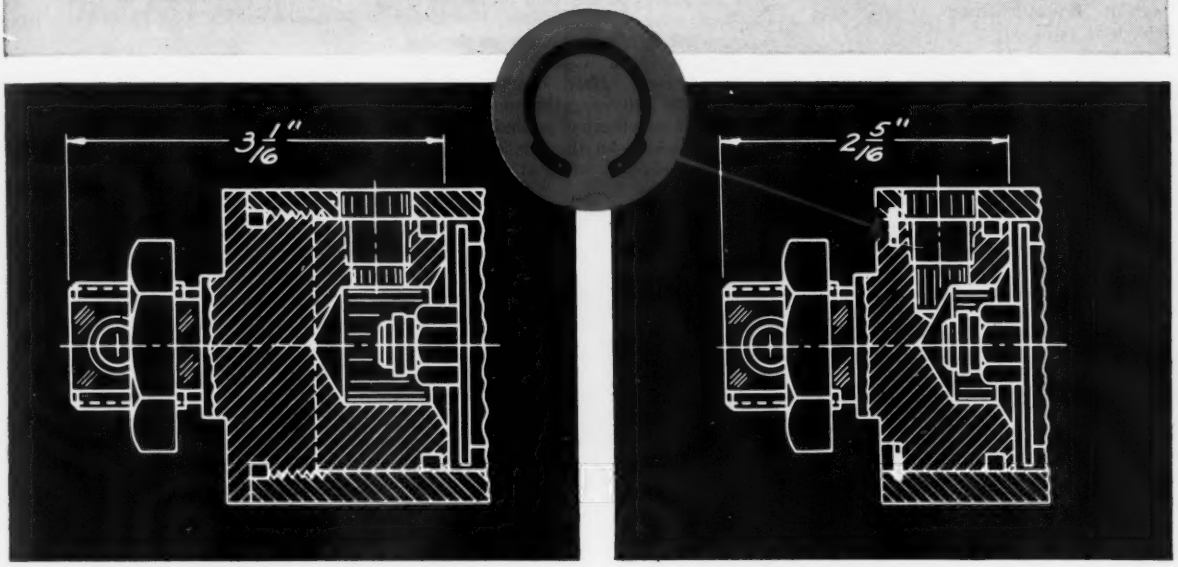
Lubricants for Metalworking; Applications in the Non-ferrous Metal Industries. T. Broom. *Metal Treatment*, Feb., 1954, p. 61.

A Plastic-Flow Problem Arising in the Theory of Discontinuous Machining. E. H. Lee. *Trans. ASME*, Feb., 1954, p. 189. 14 refs.

Production of Gas Turbine Blades; Techniques Adopted by Ruston & Hornsby, Ltd., Lincoln. B. P. Dabell and L. H. Williams. *Metal Treatment*, Dec., 1953, p. 571. Development includes discussion of the advantages of precision casting and forging of blades.

Design and Production of Light Alloy Forgings by Heavy Press Operations. A. E. Favre. *Auto. Ind.*, Mar. 1, 1954, p. 52. Alcoa's experience under the USAF program.

Waldes Truarc Rings Cut Costs $3.26 per Unit, Reduce Size and Weight of Air Cylinder!



OLD STYLE air cylinder, with thread-secured head, required costly tapping, chasing and assembly operations. Also, satisfactory maintenance of packing unit necessitated use of pipe wrenches on painted surfaces.

NEW cylinder head is secured with precision-ground Waldes Truarc Rings. This produces perfect alignment of head within the housing, difficult to obtain with screw-thread seating. Maintenance is quick and easy.

WALDES TRUARC RINGS PERMITTED THESE SAVINGS

Production Time Cut..17 minutes
Weight Saved.....1¾ lb.
Length Shortened.....1½ inches
Cost Saved.....$3.26 unit

■ The A. K. Allen Company of Brooklyn, New York, maker of *AllenAir* cylinders, now uses two Waldes Truarc Inverted Rings (series 5008) to secure heads rigidly within tubes.

■ TRUARC Rings, in this application, are ground parallel by A. K. Allen to .001 tolerance. In a static hydraulic bursting test, the 3" unit (recommended for 350 p.s.i.) withstands a pressure of 2000 p.s.i. And at bursting-point, the brass groove gives way; the Truarc Ring remains intact.

■ Waldes Truarc Retaining Rings are precision-engineered . . . quick and easy to assemble and to disassemble. They can be used over and over again. There's a Waldes Truarc Ring to answer every fastening problem.

■ Find out what Waldes Truarc Retaining Rings can do for you. Send your blueprints to Waldes Truarc engineers.

For precision internal grooving and undercutting . . . Waldes Truarc Grooving Tool

SEND FOR NEW CATALOG

WALDES
TRUARC
REG. U. S. PAT. OFF.
RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS AND PLIERS ARE PROTECTED BY ONE OR MORE OF THE FOLLOWING U. S. PATENTS: 2,382,947; 2,382,949; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,509,081; AND OTHER PATENTS PENDING.

AE-055

Waldes Kohinoor, Inc., 47-16 Austel Pl., L. I. C. 1, N. Y.

Please send me the new Waldes Truarc Retaining Ring catalog.

(Please print)

Name.....
Title .....
Company .....
Business Address.....
City..... *Zone*..... *State*.....

DEPARTMENT OF TECHNOLOGY CLIFFORD POLI LIBRARY

Extruded Engine-Rings; The Use of Steel Extrusions in the Production of Heavy-Section Circular Parts for Gas-Turbines. P. V. Brown. *Aircraft Prod.*, Mar., 1954, p. 106.

Internal Stresses in Some Types of Forging. I. Charles Sykes. *Steel Processing*, Feb., 1954, p. 101.

Investment Casting; When and How to Use It. Edward Engel. *Tool Engr.*, Feb., 1954, p. 77.

Magnesium Forming. IV—Deep Drawing and Miscellaneous Methods. Francis L. Coenen. *Tool Engr.*, Feb., 1954, p. 68.

Straightening Extruded Shapes, With Details of Some Recent Designs of Straightening and Stretching Machines. Leo Hoffmann. *Mech. Eng.*, Feb., 1954, p. 139.

Application of Isothermal Heat-Treatment in the U.S.A. Leon Rosseau. *Metal Treatment*, Feb., 1954, p. 75.

Heat-Treatment of High-Speed Steel. II. S. G. Cope. *Metal Treatment*, Feb., 1954, p. 67. Analysis includes influence of conditions prior to the heat treatment and the effects on the final properties of the steels used.

Influence of Microstructure on the Hot Strength of Steel. Georges Delbart and Michel Ravery. *Metal Treatment*, Dec., 1953, p. 579. Investigation under IRSID auspices of the effects of preliminary heating and soaking on the rate of creep of low-carbon Cr-Mo steels at 450°C. and 575°C.

ENGINEERS

Republic Aviation
Expanding
Guided Missiles Division

Here is a unique opportunity for growth in today's fastest growing field for engineers with aircraft, missiles or related experience. Our Guided Missiles Division is forging ahead with new Government contracts.

Responsible positions are open for:

Electronics Engineers **Electromechanical Designers**
Servo Engineers **Analogue Computer Engineers**
Aerodynamicists **Flutter Engineers**
Instrument Engineers **Stress Engineers**
Operations Research Engineers

CHIEF TECHNICAL ENGINEER

Responsible for Administration of Departments assigned to him and technically able to evaluate existing missile systems, conceive new systems, and supervise development of complete systems, as well as testing of systems. Must primarily possess extensive technical knowledge and experience in fields of Electronics and Servo-Mechanisms. Also required is broad experience in over-all missile systems and knowledge of state of the art, especially as related to sections of engineering for which he is responsible.

Please forward complete résumé to attention of Mr. E. Eddy

Guided Missiles Division
99 Church Street
New York 7, N. Y.

REPUBLIC
AVIATION CORPORATION

Modern Welding of Aircraft Components. W. P. Brotherton. *Steel Processing*, Feb., 1954, p. 92. Ryan Aeronautical Company's experience.

Nitrogen-Arc Welding of Copper. Edwin Davis and C. A. Terry. *Brit. Welding J.*, Feb., 1954, p. 21. 19 refs. Results of an experimental investigation.

Nitrogen-Arc Welding of Copper. K. Winterton. *Brit. Welding J.*, Feb., 1954, p. 87.

A Progress Report on Shielded-Tungsten Arc Welding. H. A. Huff, Jr., and A. N. Kugler. *Prod. Eng.*, Feb., 1954, p. 170. Evaluation in terms of use on aluminum, magnesium, stainless steel, high-temperature alloys, and thin-gage metals generally.

Self-Adjusting Welding Arcs. J. C. Needham and W. G. Hull. *Brit. Welding J.*, Feb., 1954, p. 71.

Spot Welding of Low-Alloy High-Tensile Steels. P. Joumat. *Brit. Welding J.*, Feb., 1954, p. 64.

Production Engineering

Index Tolerance Chart Simplifies Production. Allen Johnson. *Tool Engr.*, Feb., 1954, p. 53. Optimum inspection, control, and cost factors.

Practical Uses of Statistical Quality Control. Martin H. Saltz. *Tool Engr.*, Feb., 1954, p. 49. Arma Corp. program to meet USAF requirements.

The Training of the Process Control Engineer and the Presentation of Control Theory. G. L. d'Ombrian. *Trans. Soc. Inst. Tech.*, Sept., 1953, p. 90; Discussion, p. 100.

Tooling

On the Analysis of Cutting-Tool Temperatures. E. G. Loewen and M. C. Shaw. *Trans. ASME*, Feb., 1954, p. 217. 30 refs.

Predicting the Angle of Chip Flow for Single-Point Cutting Tools. L. V. Colwell. *Trans. ASME*, Feb., 1954, p. 199.

Tooling Transport Aircraft; Planning Problems Encountered in Tooling Variance of a Basic Type of Aircraft; Forming Titanium Parts. J. R. Franks and C. S. Glasgow. *Aircraft Prod.*, Mar., 1954, p. 120.

Propellers

Apparatus for Checking Contours of Propeller Models. P. Langsethmo. (*Teknisk Ukeblad*, Sept. 24, 1953, p. 763.) *Engr. Dig.*, Feb., 1954, p. 55. Design and operational features.

Reference Works

Evoluzione Tecnica dei Mezzi di Trasporto Aereo (On the Technical Evolution of Transport Aircraft). Giovanni P. Casiraghi. *L'Aerotecnica*, Oct., 1953, p. 330. 320 refs. In Italian. A 31-page survey of design, structural, aerodynamic, and other factors related to the development of essential characteristics of speed, safety, comfort, and economy, with an extensive bibliography.

A COMPLETE MEDIA PACKAGE

FOR YOUR

Aviation Marketing Program

AERONAUTICAL ENGINEERING REVIEW

For your monthly advertising messages to the aircraft industry's engineering and design personnel—the men who influence buying.

AVIATION MARKET GUIDE Available!

24 pages of FACTS on your market and REVIEW.

Write for your free copy TODAY!

AERONAUTICAL ENGINEERING CATALOG

Prefiles and distributes your aircraft products catalog to aviation's buyers and specifiers.

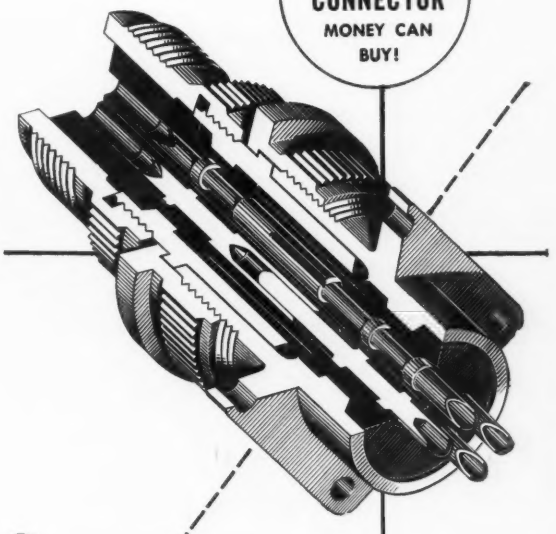
7,000 copies are distributed annually to aircraft engineers, designers, technicians and purchasing agents in all leading aircraft, engine and parts companies, Government aviation departments and leading air lines.

OFFICIAL PUBLICATIONS:

INSTITUTE OF THE AERONAUTICAL SCIENCES

2 East 64th Street New York 21, N.Y.

The Finest ELECTRICAL CONNECTOR MONEY CAN BUY!



SCINFLEX ASSURES LOW MAINTENANCE BECAUSE IT PERMITS SIMPLICITY

When operating conditions demand an electrical connector that will stand up under the most rugged requirements, always choose Bendix Scinflex Electrical Connectors. The insert material, an exclusive Bendix development, is one of our contributions to the electrical connector industry. The dielectric strength remains well above requirements within the temperature range of −67°F to +275°F. It makes possible a design increasing resistance to flashover and creepage. It withstands maximum conditions of current and voltage without breakdown. But that is only part of the story. It's also the reason why they are vibration-proof and moisture-proof. So, naturally, it pays to specify Bendix Scinflex Connectors and get this extra protection. Our sales department will be glad to furnish complete information on request.

• Moisture-Proof • Radio Quiet • Single Piece Inserts • Vibration-Proof • Light Weight • High Insulation Resistance • High Resistance to Fuels and Oils • Fungus Resistant • Easy Assembly and Disassembly • Fewer Parts than any other Connector • No additional solder required.

BENDIX SCINFLEX ELECTRICAL CONNECTORS

SCINTILLA DIVISION of Bendix AVIATION CORPORATION
SIDNEY, NEW YORK

Export Sales: Bendix International Division, 205 E. 42nd Street, New York 17, N. Y.
FACTORY BRANCH OFFICES: 117 E. Providencia Ave., Burbank, Calif. • Stephenson Bldg., 6560 Cass Ave., Detroit 2, Michigan • 512 West Ave., Jenkintown, Pa. • Brouwer Bldg., 176 W. Wisconsin Avenue, Milwaukee, Wisconsin • American Building, 4 South Main St., Dayton 2, Ohio • 8401 Cedar Springs Road, Dallas 19, Texas

Rotating Wing Aircraft

Development Problems of the Large Helicopter. L. L. Douglas. *Aero. Eng. Rev.*, Apr., 1954, p. 60. Requirements of multiengined reliability, load - carrying capabilities, and economic transportation related to factors of design coordination, development testing, and quality control.

Economic Aspects of Helicopter Operations in India with Special Reference to Operations in the Assam Area. P. Nilakantan and M. S. Ekbote. *J. Aero. Soc. India*, Nov., 1953, p. 69. Includes comparative specifications and performance data and direct operating costs for four helicopter types.

Economic Considerations of the Transport Helicopter. James B. Edwards. *Aero. Eng. Rev.*, Apr., 1954, p. 76. Discussion of the factors of scientific development, public acceptance, and operational profit related to those of safety, comfort, speed, and economy.

Electrical Strain Gage Analysis of the SG VI Helicopter. G. A. Brewer. *Am. Helicopter*, Jan., 1954, p. 6. Structural analysis includes diagrams and charts.

Investigation of Lateral and Directional Behaviour of Single Rotor Helicopter (Hoverfly Mk. I). J. Zbrozek. *Gt. Brit., ARC R&M 2509* (June, 1948), 1953. 20 pp. BIS, New York. $1.40.

Rotor Blade Motion in a Vertical Sharp-edged Gust; A Study of the Dynamics of Helicopter Blade Flapping with a Method of Deriving Maximum Gust Deflexion. II—Tapered and Twisted Blades. P. R. Payne. *Aircraft Eng.*, Feb., 1954, p. 41.

ENGINEERS

Wanted by AiRESEARCH Manufacturing Company
Los Angeles, California, and
Phoenix, Arizona

AERO-THERMODYNAMICIST
Experienced in the aerodynamic design of turbo-machinery.

•

DEVELOPMENT ENGINEER
PNEUMATIC VALVES
Experience desirable in pneumatic servomechanism and in mechanical pneumatic design.

•

VIBRATION ENGINEER
Experience in vibration analysis, theoretical analysis and vibration instrumentation and testing.

•

DEVELOPMENT ENGINEER
TURBO-MACHINERY
Experience in mechanical engineering and development in testing and test facilities.

•

STRESS ANALYST
Experience in stress and vibration problems of turbo-machinery structure and rotating components.

•

GEAR DESIGNER
HIGH SPEED GEARING SPECIALIST
Experience in gear geometry and stress analysis. Knowledge of gear production methods essential.

•

MECHANICAL ENGINEERS
5 years experience in the design and development of small mechanical mechanisms and fabrication of small gears for use at high speed.

Please direct your inquiry to AiResearch Manufacturing Company of Arizona, Skyharbor Airport, 402 South 36th Street, Phoenix, Arizona or AiResearch Manufacturing Company, 9851 S. Sepulveda Blvd., Los Angeles, Calif., Attention: Personnel Department. Please include a resume of experience as well as personal data.

Safety

Airplane Design in Relation to Safety. R. W. Rummel. *Aero. Eng. Rev.*, Apr., 1954, p. 70. Optimum design-for-safety recommendations urging simplicity of design and improvements in warning devices to better take into account human and operational factors.

Comparison of Model and Full-scale Spin Recoveries Obtained by Use of Rockets. Sanger M. Burk, Jr., and Frederick M. Healy. *U.S., NACA TN 3068*, Feb., 1954. 63 pp.

Flight on the Back Side of the Power-Required Curve. E. T. Martin. *Skyways*, Mar., 1954, p. 13.

Licensed Aircraft Maintenance Engineers and Certificates of Safety. J. Norman. *J. SLAE*, Jan., 1954, p. 2.

Typical Impacts of Jet Aircraft Land Crashes. Walton L. Jones. *J. Av. Med.*, Dec., 1953, p. 474.

Space Travel

Reliability and Spaceship Design. Vince Story. *J. Space Flight*, Feb., 1954, p. 2. Analysis of total reliability covering the propulsion, guidance, and control systems.

Structures

Analysis of Thin Square Plates under Normal Pressure and Provided with Edge Frames of Finite Stiffnesses in the Plane of the Plates. Sigge Eggwertz and Artur Norr. *Sweden, Flygtekniska Försöksanstalten, FFA Meddelande NR 50*, 1953. 34 pp. 21 refs.

The Determination of Torsion Constants for Bulbs and Fillets by Means of an Electrical Potential Analyser. P. J. Palmer. *Aluminium Development Assn. Res. Rep. 22*, Dec., 1953. 24 pp. Application of the analogical apparatus to structural testing, with an analysis of the mathematics of the torsion problem.

The Load-Deflection Relationship for a Partially Plastic Rolled-Steel Joist. J. W. Roderick. *Brit. Welding J.*, Feb., 1954, p. 78.

On the Use of Hodographs in Problems of Plane Plastic Strain. A. P. Green. *J. Mech. & Phys. Solids*, Jan., 1954, p. 73. 11 refs.

Summary of the Theoretical Work done on the Stability of Thin Plates, 1939 to 1946. D. M. A. Leggett. *Gt. Brit., ARC R&M 2784* (Sept., 1950), 1953. 8 pp. 48 refs. BIS, New York. $0.65.

Bars & Rods

Dynamic Analysis of the Buckling of Laterally Loaded Flat Arches. N. J. Hoff and Victor G. Bruce. *J. Math. & Phys.*, Jan., 1954, p. 276. ONR-sponsored research at the Polytechnic Institute of Brooklyn, for the illustrative case of the laterally-loaded, slightly-curved bar.

The Plastic Torsion of Anisotropic Bars. R. Hill. *J. Mech. & Phys. Solids*, Jan., 1954, p. 87.

Zur Torsion von Stäben. Alfred Herzig. *ZAMM*, Dec., 1953, p. 410. Con-

PAC Air Flow Controller helps BOEING save 78% of the WEIGHT of a mighty jet engine starter

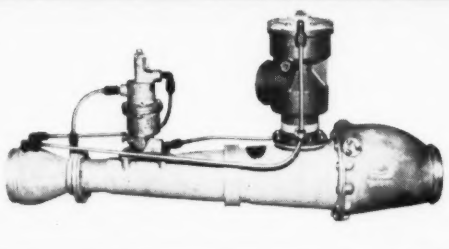
...and ups its output 5-fold, too!

Not so long ago it took a lumbering giant of a machine to start Boeing B-52's. The starter weighed 12,000 pounds, yet for this application provided only a skimpy 57 air horse power.

Today, thanks to brilliant engineering and *the very finest components,* Boeing starts the tremendous Pratt & Whitney J-57 jet engines with a new "air supply cart" which, despite its trim 2600 pound weight, delivers a hard-hitting 280 air horse power! PAC is proud to have had a part in the development of this outstanding jet engine starter through engineering counsel and manufacture of a major component.

An engineered-to-the-job component—vital to the success of the new Boeing unit—is the PAC Air Flow Controller.

This unit is used with a ground air supply system to limit the compressor flow in the event demand falls below a specified minimum. A wide variety of performance curves can be produced with this basic design to match the characteristics of the air supply compressor.



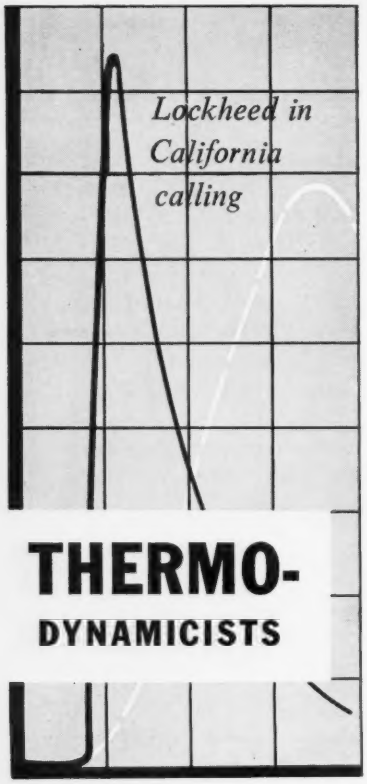
If you have a problem calling for engineering know-how and productive capacity call PAC!

Aero-Pneumatics Division

Pacific Airmotive Corporation

2940 North Hollywood Way, Burbank, California

Other Divisions: Oakland and Chino, California • Seattle, Washington • Kansas City, Kansas • Linden, New Jersey



THERMO-
DYNAMICISTS

to work on

nuclear energy · jet transports
super-sonic fighters
continuing development of
the Super Constellation and other
production models

These career positions have been created by Lockheed's program of diversified development—a program that means more scope for your ability and more opportunity for promotion because it *is* diversified.

In addition to more opportunity, you receive

increased pay rates now in effect
generous travel and moving allowances
the opportunity for you and your family to enjoy life in Southern California

Lockheed invites qualified thermodynamicists to write for information concerning these positions

Mr. E. W. Des Lauriers
Engineering Recruiting, Dept. AER-FT-5
Lockheed Aircraft Corporation
Burbank, California

LOCKHEED
AIRCRAFT CORPORATION
BURBANK, CALIFORNIA

formal mapping method of computing the torsional stiffness of a bar of arbitrary cross section as well as deformation, for the cases of a semicircle, a quarter of a circle, and a circle with a radial split.

Beams & Columns

The Analysis of Shear Distribution for Multi-Cell Beams in Flexure by means of Successive Numerical Approximations. Derek R. Samson. *J. RAeS*, Feb., 1954, p. 122.

Application of Maclaurin Series in Structural Analysis. K. T. Sundara Raja Iyengar. *J. Indian Inst. Sci., Sect. B*, Jan., 1954, p. 20. A direct solution of beam problems as applied to derive the theorem of three moments and slope deflection equations.

The Centre of Shear for Sections Bounded by Two Circular Arcs. L. G. Whitehead and L. A. McQuillin. *J. RAeS*, Feb., 1954, p. 138.

Impact of Finite Beams of Ductile Metal. P. S. Symonds and C. F. A. Leth. *J. Mech. & Phys. Solids*, Jan., 1954, p. 92. ONR-sponsored analytical investigation at Brown University of large plastic deformations of a uniform beam of arbitrary length subjected to a concentrated impact load at its mid-point forcing one cross section to move with a given velocity which is then maintained constant.

Intreccio di Travi Rettilinee nelle Costruzioni Aeronautiche (On the Calculation of a Grid of Rectilinear Beams in Aircraft Construction). Ermenegildo Preti. *L'Aerotecnica*, Dec., 1953, p. 418. In Italian.

Some Formulas for Large Deflections of Beam Columns. B. Saelman. *J. Franklin Inst.*, Feb., 1954, p. 125. Analyses of the cantilever beam column, the simply supported centrally loaded beam column, and the cantilever loaded by its own weight or by an ice load.

Cylinders & Shells

On the Stress Distribution in the Walls of Pressure Vessels. H. Fessler and R. T. Rose. *J. Mech. & Phys. Solids*, Jan., 1954, p. 127.

Shells with Zero Bending Stresses. M. R. Horne. *J. Mech. & Phys. Solids*, Jan., 1954, p. 117.

Torsion of a Constrained Rectangular Box Section; An Experimental Investigation of the Stresses due to Torsion in a Rectangular Box Section with one end Constrained. W. L. Green and S. S. Gill. *Aircraft Eng.*, Feb., 1954, p. 34. 10 refs.

Thermodynamics

Effect of Water on Carbon Monoxide-Oxygen Flame Velocity. Glen E. McDonald. *U.S., NACA RM E53L08*, Feb. 5, 1954. 15 pp.

Equations for a Hydrogen-Bromine Flame: Computational Methods and Techniques. Edwin S. Campbell, Daniel R. Hughes, and Robert J. Buehler. *U. Wis. NRL Dept. Chem. Rep. CF-2109*, Oct. 19, 1953. 153 pp. 12 refs.

An Evaluation of the Soap-Bubble Method for Burning Velocity Measurements Using Ethylene-Oxygen-Nitrogen

UNUSUAL OPPORTUNITIES
FOR QUALIFIED ENGINEERS

Join the happiest aircraft family in sunny San Diego. Outstanding employee benefits including profit-sharing, low-cost group insurance and medical care, free polio insurance for yourself and family, paid tuition for university night school courses, periodic salary merit and adjustment reviews, paid vacations, transportation allowance, and many others.

JET ENGINE ANALYST

Responsible position for qualified engineers with strong aero-thermo background, familiar with turbojet engine cycle analysis, and capable of determining engine performance parameters at various flight speeds and altitudes. Must be graduate engineer with minimum of 3 to 5 years' experience in aircraft gas turbine field.

MECHANICAL DESIGN ENGINEER

Requires mechanical engineering degree and five years' experience in design of gas turbines or similar type machines. Must be capable of making layouts of complete parts and components taking into consideration manufacturing costs, weight, stress, mechanics and production problems.

WRITE TO

SOLAR
AIRCRAFT COMPANY

2200 PACIFIC HIGHWAY
SAN DIEGO, CALIFORNIA

When you write to manufacturers whose advertising appears in the **Aeronautical Engineering Review,** it will be of interest to the companies and of benefit to the Institute if you mention that you saw it in the **Aeronautical Engineering Review**

Complete RELIABILITY...

first essential in aircraft electronics

Engine-control electronic equipment is frequently installed in close proximity to the turbojet engine. Therefore, electronic components must be designed and constructed to function with *complete reliability* under extreme ambient conditions. However, the degree of reliability attained depends largely upon the attention given to detail in applying these five major design principles to every phase of equipment development:

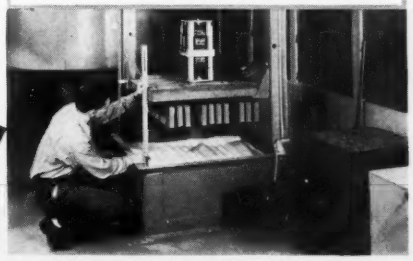
1. Conception of basically simple circuitry to accomplish desired control functions.
2. Rugged design of mechanical details.
3. Selection of components based upon extensive environmental and life tests.
4. Operation of all components well below their maximum rating.
5. Adequate performance tests of production units under dynamic operating conditions.

Strict adherence to these principles has enabled us to achieve extreme reliability in all our aircraft electronic equipment. We believe our years of concentrated research, development and tests devoted exclusively to automatic control systems for jet engines can be of real value in solving your control problems. Our engineering counsel and extensive manufacturing and test facilities are at your service. We welcome your inquiry.

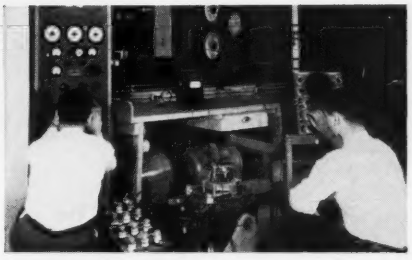
TEMPERATURE CONTROL AMPLIFIER (*Illustrated above*). Modulates exhaust nozzle area of a turbojet engine to maintain a constant turbine exit temperature. Input signal is derived from thermocouples. Output controls a servo which supplies hydraulic power to the exhaust nozzle positioning actuators.

TEST SPECIFICATIONS. **MIL-E-5009A:** Altitude, ignition proof, sand and dust, humidity, sustained acceleration, impact. **MIL-E-5272A:** Salt Spray. **MIL-E-5007A:** General specification. **MIL-I-6181:** Radio interference.

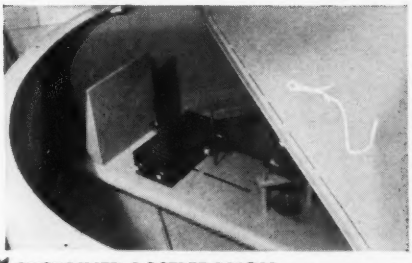
SIMULATED OPERATING CONDITIONS PROVE COMPONENT PERFORMANCE



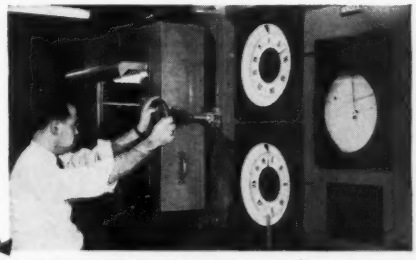
IMPACT. Unit must withstand impact shocks of 30g for a time duration of not less than 10 milliseconds.



VIBRATION. Operational accuracy guaranteed at 5g from 20 to 55cps and at 10g from 55 to 225cps.



SUSTAINED ACCELERATION. Unit must operate satisfactorily while subjected to sustained acceleration of 8g along its longitudinal axis, 10g along its vertical axis, and 5g along its horizontal axis.



FLIGHT TEST CHAMBER. Unit performance checked under simulated flight conditions within a temperature range of minus 65° F. to plus 200° F., a relative humidity of 95%, and at all altitudes up to 50,000 feet.

MANNING, MAXWELL & MOORE, INC.

AIRCRAFT PRODUCTS DIVISION • STRATFORD, CONN. • DANBURY, CONN. • INGLEWOOD, CALIF.

OUR AIRCRAFT PRODUCTS INCLUDE: TURBOJET ENGINE TEMPERATURE CONTROL AMPLIFIERS • ELECTRONIC AMPLIFIERS PRESSURE SWITCHES FOR ROCKETS, JET ENGINE AND AIRFRAME APPLICATIONS • PRESSURE GAUGES THERMOCOUPLES • HYDRAULIC VALVES • JET ENGINE AFTERBURNER CONTROL SYSTEMS.

and Methane-Oxygen-Nitrogen Mixtures. Dorothy M. Simon and Edgar L. Wong. *U.S., NACA TN 3106*, Feb., 1954. 30 pp. 22 refs.

Review of the Reaction Kinetics and Transport Properties of a Hydrogen Bromine Flame. Edwin S. Campbell and J. O. Hirschfelder. *U. Wis. NRL Dept. Chem. Rep. CF-2108*, Nov. 17, 1953. 65 pp. 71 refs.

Vibrational Spectra of Tetrafluoroethylene and Tetrachloroethylene. D. E. Mann, Nicolo Acquista, and Earle K. Plyler. (*Res. Paper 2474.*) *U.S., NBS J. Res.*, Feb., 1954, p. 67. 38 refs. *ONR*-sponsored investigation; includes tables of thermodynamic functions.

Heat Transfer

Analogue Solution of Heat Conduction Problems. A. E. Guile and E. B. Carne. *Elec. Eng.*, Mar., 1954, p. 224. Abridged. Basic principles; application to the analysis of the thermal system of a simple cartridge fuse.

Charts and Formulae for Evaporation Processes. I, II. E. Kirschbaum. (*Z. VDI*, Sept. 21, 1953, p. 927.) *Engr. Dig.*, Jan., Feb., 1954, pp. 21, 69. 20 refs. Experimental diagrammatic approach to analyses.

The Specific Heat and Thermal Conductivity of Graphite. P. G. Klemens. *Australian J. Phys.*, Dec., 1953, p. 405.

A System of Non-Linear Partial Differential Equations Arising in Heat Transfer. S. Katz and A. M. Peiser. *J. Math. & Phys.*, Jan., 1954, p. 256.

A Transient-Flow Method for Determination of Thermal Constants of Insulating Materials in Bulk. I—Theory. J. H. Blackwell. *J. Appl. Phys.*, Feb., 1954, p. 137. 14 refs.

Wind Tunnels & Research Facilities

Corrections for Symmetrical Swept and Tapered Wings in Rectangular Wind Tunnels. W. E. A. Acum. *Gt. Brit., ARC R&M 2777* (Apr., 1950), 1953. 33 pp. BIS, New York. $2.00.

Effects of Air Humidity in Supersonic Wind Tunnels. Julius Lukasiewicz and J. K. Royle. *Gt. Brit., ARC R&M 2563* (June, 1948), 1953. 35 pp. 15 refs. BIS, New York. $2.25.

Electron-Optical Shadow Method of Magnetic-Field Mapping. L. Marton, J. Arol Simpson, and S. H. Lachenbruch. (*Res. Paper 2478.*) *U.S., NBS J. Res.*, Feb., 1954, p. 97. Experimental development of method applicable to the problem of interpretation of fluid dynamic interferograms.

Impiego del Ghiaccio Secco nella Visualizzazione delle Correnti d'Aria (On the Use of the Dry Ice for the Visualization of Air Streams). A. Sellerio. *L'Aerotecnica*, Dec., 1953, p. 398. In Italian.

Faster Than Sound. Willis Brewbaker and Alvin Platnick. *Taylor Tech.*, Winter, 1954, p. 9. The NOL supersonic wind tunnel at White Oak, Md.; equipment and instrumentation, including details of control system.

The 9 × 3 in. Induced-flow High-Speed Wind Tunnel at the National Physical Laboratory. D. W. Holder and R. J. North. *Gt. Brit., ARC R&M 2781* (June, 1949), 1953. 23 pp. 24 refs. BIS, New York. $1.80.

Operations Research. Philip M. Morse. *Appl. Mech. Rev.*, Mar., 1954, p. 89. Evaluative analysis, including techniques used, applicable industrial problems, linear programming, and production planning.

Symposium on High Speed Aerodynamics; Summary of Proceedings, Ottawa, Can., Feb. 26–27, 1953. *Canada, NAE HSAL Rep.*, June, 1953. 76 pp. 34 refs. Partial contents: High Mach Number Flows in Wind Tunnels, J. D. Stewart. Development of Transonic Wind Tunnel Testing Technique, J. Lukasiewicz and J. A. Laurmann. Design and Calibration of Supersonic Wind Tunnel Nozzles, J. G. LaBerge. Wind Tunnels in the High Speed Aerodynamics Laboratory, J. Lukasiewicz.

The Use of Stator-Blade Control to Obtain Wide Range of Compressor Performance for Wind-Tunnel Application. A. W. McCoy and M. J. Brunner. *Trans. ASME*, Feb., 1954, p. 233. 9 refs. Design and development of axial-flow compressors to provide wide ranges of pressure ratio and volume flow as applied in the 16 × 16 foot Propulsion Wind Tunnel at the Arnold Engineering Development Center at Tullahoma, Tenn.

Wind Tunnel Balance Design—The Simultaneous Measurement of Forces and Moments. C. G. Saunders. *J. RAeS*, Feb., 1954, p. 141.

Wind-Tunnel Drives. L. A. Kilgore and H. C. Brunner. *Westinghouse Engr.*, Mar., 1954, p. 72. Includes tables, charts, and diagrams of comparative and operational data, with applications.

Wind Tunnels—Why and Where. C. A. Scarlott. *Westinghouse Engr.*, Mar., 1954, p. 66. Survey analysis of tunnel design specialization, physical locations, sizes, operating conditions, functions, and other factors.

The World's Largest Wind Tunnel. W. J. Walker. *Westinghouse Engr.*, Mar., 1954, p. 79. Design and construction details of the USAF Propulsion Wind Tunnel at Tullahoma, Tenn., with a schematic drawing of the transonic compressor, drive motors, and the supersonic compressors.

An Authorized Binding for Aeronautical Engineering Review

Arrangements have been made by the Institute of the Aeronautical Sciences for subscribers to have their Reviews bound into distinctively designed books.

Twelve issues, January through December, bound in best grade red washable buckram, imprinted with your name on cover, cost but $3.65 per volume.

Ship Reviews parcel post insured. Within 30 days after receipt, bound volumes will be shipped prepaid anywhere in the U.S.A. Full remittance must accompany order.

Publishers' Authorized Bindery Service
(Binders of all Journals)

308 West Randolph St. **Chicago 6, Ill.**

...curious about TRANSISTORS?

If you are interested in any of the following Transistor applications, you should contact Hydro-Aire NOW!

Mono-stable and bi-stable flip flop circuits

•

Binary Scalers

•

Clock Generators

•

Microphone Amplifier

•

Low, medium and high gain Standard Amplifiers

•

Decade Amplifier

•

Logarithmic Amplifier

Please address your inquiries:

CHIEF CONSULTING ENGINEER

Transistor Development and Application Division

HYDRO-AIRE *Inc.*

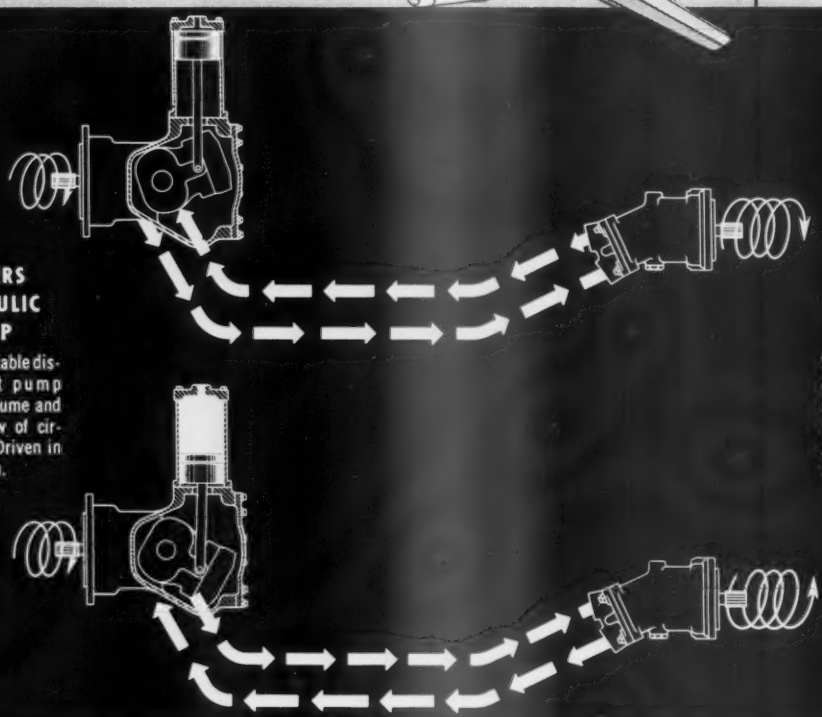
3000 Winona Avenue, Burbank, Calif.

Subsidiary of Crane Co.

CONSULTANTS ON TRANSISTOR APPLICATIONS

VICKERS hydraulic drives for aircraft

instantaneously reversible drive



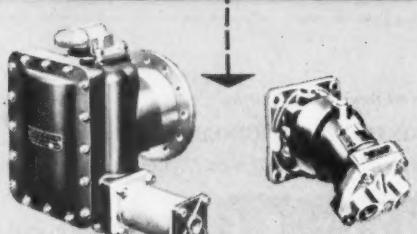
VICKERS HYDRAULIC PUMP

Two-way variable displacement pump regulates volume and reverses flow of circulating oil. Driven in one direction.

VICKERS HYDRAULIC MOTOR

Variable horsepower output (constant torque) characteristics from stall to maximum speed in both directions.

Vickers Hydraulic Drives for aircraft have very high horsepower/weight ratios. They are infinitely variable and reversible without gear changes or clutch mechanisms, may have either manual or automatic speed controls, and are so sensitive that they can be actuated by a few milliamps of signal current. Response is extremely rapid and precise due to low inertia of axial piston design of both pumps and motors. Motors deliver full torque over entire speed range. There is no radio interference. Vickers Hydraulic Drives have a variety of applications including cabin compressors, gun turrets, control surfaces, etc.



Vickers Variable Displacement Piston Type Pump

Vickers Constant Displacement Piston Type Motor

NEW

WRITE FOR BULLETIN A-5200 B

VICKERS Incorporated

DIVISION OF THE SPERRY CORPORATION

1414 OAKMAN BLVD. • DETROIT 32, MICH.

4535

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Aeronautical Reviews — BOOKS

Book Notes

ELECTRONICS

Ultra High Frequency Propagation. Henry R. Reed and Carl M. Russell, assisted by W. M. Browne and J. W. Plummer. New York, John Wiley & Sons, Inc., 1953. 562 pp., diagrs., figs. $9.50.

The primary purpose of this book is to present current information on UHF radio wave propagation, with a review of all other related system parameters. An additional intention is to show, through presentation of theory and illustrative examples, how to determine operational ranges when using UHF communications systems. All of the authors are connected with the U.S. Naval Air Test Center, Patuxent River, Md. Dr. Reed is a consultant to the NATC and also Professor of Electrical Engineering, University of Maryland. Russell is Chief Engineer, Electronics Test Division, and Browne is in the Radio Propagation and Meteorology Section. Plummer is Head of the Radio and Communications Branch. Because of the authors' background in aviation, they have drawn upon aircraft to illustrate mobility of a source or receiver of energy. However, the reasoning is applicable to ships, automobiles, trains, missiles, and the like. The information contained in this volume should be of value for courses in electrical engineering, to commercial pilots, to engineers in aircraft manufacturing companies, to equipment installation engineers, and to industrial organizations doing research in aviation electronic communications.

Contents: (1) An Introduction to UHF Communications and the System Concept. (2) General Aspects of Propagation. (3) Meterological Theory. (4) Antennas and Radiation Phenomena (Ground Reflection Behavior). (5) Multiple Propagation (Ground-to-Air, Air-to-Ground, and Ground-to-Ground Propagation). (6) Comparison of VHF and UHF Propagation. Dipole-to-Dipole (Ground-to-Air and Air-to-Ground Propagation). (7) Complex Antennas (Linear Arrays). (8) Complex Antennas (Circularly Polarized Antennas). (9) System Comparison, Operation, and Design of UHF Complex Antennas. (10) Air-to-Air Propagation. (11) Lobe Modulation Interference and Design Considerations. (12) Effects of Meteorological Conditions on Experimental Flight Data. (13) General Operational Considerations. (14) Illustrative Systems Design Problems.

Communication Theory. Papers read at a Symposium on "Applications of Communication Theory" held at the Institution of Electrical Engineers, London, September 22nd–26th, 1952. Edited by Willis Jackson. London, Butterworths Scientific Publications; New York, Academic Press, Inc., 1953. 532 pp., figs. $11.

Contents: Opening Address, Willis Jackson. A Summary of Communication Theory, D. Gabor. The Definition of Rate of Information in the Presence of Noise, P. H. Blundell. A Comparison of Transmission Systems, Z. Jelonek. Information Theory of Noise Reduction in Modulation Systems, S. Goldman. The Effects of Relaxation Time on the Relative Efficiency of Binary PCM, PIM and PPM, D. M. MacKay. A Method for the Construction of Minimum-Redundancy Codes, D. A. Huffman. Efficiency of Noise-Reducing Codes, A. E. Laemmel. Deltamodulation—A Method of PCM Transmission Using the One-Unit Code, F. de Jager. A Recent Development in Communication Technique, C. W. Earp. Non-Linear Distortion in Pulse Code Modulation Systems, H. W. F. van't Groenewout. A Theoretical Comparison Between Auto-Correlation and Square Law Types of Detection, D. E. Hampton. Communication in the Presence of Additive Gaussian Noise, R. M. Fano. Exhaustion Methods of Selecting Signals from Noisy Backgrounds, W. Meyer-Eppler. Measurement of Correlation Functions of Modulated Carriers and Noise Following a Non-Linear Device, R. A. Johnson and D. Middleton. Integration in Pulse Radar Systems, A. E. Bailey. Video Signal Integration Using Acoustic Delay Lines and Dynamic Magnetic Storage, R. L. Beurle. Video Signal Integration Using a Storage Tube, P. L. Waters. Statistical Methods for the Detection of Pulsed Radar in Noise, D. Middleton. Group Synchronizing of Binary Digital Systems, R. H. Barker. Relationship Between the Distortion and the Characteristics of a Transmission System and its Application to Television, M. Cotte. Channel Capacity and Propagation Time, K. Küpfmüller. Delay Time and Transient Time in Electrical Filters with Phase Distortion, T. Laurent. Communication Theory of Transmission of Simple Drawings, J. Loeb. Some Possibilities for the Compression of Television Signals by Recoding, E. C. Cherry and G. G. Gouriet. Note on a Method of Coded Colour Television Transmission, G. Valensi (presented by J. Lalou). A Theory of Hearing, W. H. Huggins. The 'Internal Information' of English Words, D. A. Bell. Some Statistical Aspects of Conversational Speech, J. Berry. The Information-Bearing Elements of Speech, G. E. Peterson. Mechanical Speech Recognition, D. B. Fry and P. Denes. Automatic Recognition of Spoken Digits, K. H. Davis, R. Biddulph, and S. Balashek (presented by G. Raisbeck). Some Aspects of the Behaviour of Telephone Users as Affected by the Physical Properties of the Circuit, D. L. Richards. Measurement of the Communication Rate of a Speech Link—A Preliminary Appraisal of the Problem, D. L. Richards and J. Swaffield. The Synthesis of Speech from Signals Which Have a Low Information Rate, W. Lawrence. Generators of Information, D. M. MacKay. An Informational Theory of the Statistical Structure of Language, B. Mandelbrot. Semantic Information, Y. Bar-Hillel and R. Carnap. Application to Optics of Certain Results and Methods of Information Theory, A. Blanc-Lapierre. Concluding Discussion.

Applied Electronics; A First Course in Electronics, Electron Tubes, and Associated Circuits. Truman S. Gray. 2nd Ed. A Publication of the Technology Press, M.I.T. New York, John Wiley & Sons, Inc., 1954. 881 pp., diagrs., figs. $9.00.

Radio Receiver Design. Part 1, Radio Frequency Amplification and Detection. K. R. Sturley. 2nd Ed., Revised. New York, John Wiley & Sons, Inc., 1953. 667 pp., diagrs., figs. $10.

FUELS

Petroleum and Performance in Internal-Combustion Engineering. E. M. Goodger. London, Toronto, Butterworths Scientific Publications, 1953. 295 pp., diagrs., figs. 32*s*. 6*d*.

This book has been written to provide a background for more specialized studies at postgraduate level and to help to fill the gap between the popular type of handbook and the multivolume work of reference. The major petroleum-based liquid fuels—in the range from gasoline to fuel oil—are covered, and their important engine applications are shown. Liquefied petroleum gases and substitute fuels are also mentioned, and an indication is given of present trends in the use of nonpetroleum fuels for ram-jet units and rocket motors. Information on each fuel and engine is presented in the same order throughout the chapters, enabling direct comparisons to be made in many cases. Some stress is laid upon the problems met in aviation, as developments in this field have been most advanced. In connection with this, the author is Senior Lecturer in the Department of Aircraft Propulsion, College of Aeronautics, Cranfield.

The first section of the book deals with the techniques employed in the winning and refining of crude oil, and describes the significant properties, testing, and distribution of the finished products. A discussion of the chemical nature of hydrocarbon materials is included. The second section opens with a survey of thermodynamic processes, showing their application to engine mechanisms for the effective conversion of heat energy to mechanical power. The following chapters cover the chemical production of this heat energy, and trace the combustion performance of fuels up to the selection of criteria for purposes of fuel rating. The section continues by considering the processes involved in the supply of fuel to the combustion zone, and their influence upon combustion performance. The final chapter summarizes the fuel requirements of engines and shows how the specification of each type of fuel has been evolved in order to ensure its satisfactory application. References are given for most chapters, and the index is extremely detailed.

For Information on IAS Library Service Facilities, see page 141

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

The INSTITUTE of the AERONAUTICAL SCIENCES

Announces

Publication of the

1954 EDITION

of the

AERONAUTICAL ENGINEERING CATALOG

COMPLETELY REVISED AND ENLARGED to include new items of equipment, new companies, and changes of address, the 1954 AERONAUTICAL ENGINEERING CATALOG is a complete self-contained informational service on aviation's components manufacturers and the products they are equipped to supply. Order your copy today. The supply is limited.

FEATURES:

- A MASTER FILE of company catalogs covering a wide range of aircraft products. Page after page of specifications and technical data on the products of leading manufacturers of aircraft components.
- NAMES, ADDRESSES, AND DESCRIPTION OF PRODUCTS of all principal manufacturers of aircraft and guided missile materials, components, and equipment. Arranged alphabetically by company name.
- 45,000 MANUFACTURERS' LISTINGS—A complete guide to the vendors of over 2,500 aircraft and guided missile parts, materials, accessories, and equipment. Arranged alphabetically by product. Completely cross-indexed. Reliable sources are screened carefully each year to insure accurate listing of every known company supplying the aviation industry.

ORDER YOUR COPY TODAY—THE SUPPLY IS LIMITED

I.A.S. MEMBERS: One Copy Free of Charge on Request. (Please give grade of membership, position, and company affiliation.) Additional Copies $7.50 Each.

NONMEMBERS: $7.50 Per Copy Postpaid (Check or Money Order must accompany order.)

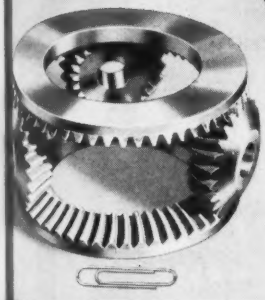
Compiled and Published Annually by:

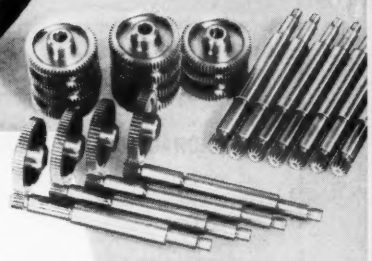
INSTITUTE OF THE AERONAUTICAL SCIENCES

2 East 64th Street **New York 21, N.Y.**

ELECTRONIC
GEARS and GEAR DRIVES

electronic gearing





1. For antenna drives
2. Guided missile gearing & drives
3. Auto-tune drives for transmitters
4. Gear trains for computers, telemetering, and servo-mechanisms...

are but a few of the many applications of Western Gear Electronic type gearing.

Write or wire for further information.

EXECUTIVE OFFICES: WESTERN GEAR, P.O. BOX 182, LYNWOOD, CALIF.

5361

GOOD GEARS SINCE 1888

...NTS AT LYNWOOD, PASADENA, BELMONT, SAN FRANCISCO (CALIF.), ...ATTLE AND HOUSTON — REPRESENTATIVES IN PRINCIPAL CITIES

WESTERN GEAR WORKS

PACIFIC-WESTERN PRODUCTS | POWER TRANSMISSION GEARS • MACHINERY •

PACIFIC GEAR & TOOL WORKS · SOUTH WESTERN GEAR WORKS

HYDRAULIC EQUIPMENT

Proceedings of the Conference on Hydraulic Servo-Mechanisms, 13 February 1953. London, Institution of Mechanical Engineers, 1953. 88 pp., illus., diagrs., figs. 7*s*. 6*d*.

Contents: Introduction. An Introduction to Hydraulic Servo-Mechanism Theory, H. G. Conway and E. G. Collinson. Variable Hydraulic Pump Servos, and a Method of Impedance Testing, C. D. Watson. Variable-Stroke Pumps for Power Transmission—Some Design Considerations, T. E. Becham. Hydraulic Servos, R. Hadekel. Some Industrial Applications of Hydraulic Servos, T. Brading and G. Parks. Some Design Considerations of Hydraulic Servos of Jack Type, N. F. Harpur. Valve Diagrams for Hydraulic Control Valves, T. E. Becham. The Forces on the Piston Track of a Variable-Capacity Type of Hydraulic Pump, P. J. Palmer. Discussion. Communications. Authors' Replies. Index.

MATERIALS

Stress Waves in Solids. H. Kolsky. Oxford, at the Clarendon Press; New York, Oxford University Press, 1953. 211 pp., illus., diagrs., figs. $5.00.

This monograph provides a summary of the classical theory and then considers how this theory can be extended to solids that are not perfectly elastic. Recent experimental work with ultrasonics, high-speed photography, and various electronic techniques is described, and the mechanism of the different microscopic processes resulting in internal friction is discussed, with special reference to the behaviour of metals and organic high polymers. Finally, the fracture effects produced by the stress pulses from explosives and high-speed projectiles are described. The subject necessarily involves some mathematical analysis, but this has been kept as simple as possible so as to be followed with ease by physics graduates. There is a bibliography of basic sources, together with subject and name indexes. The author is associated with the Butterwick Research Laboratories, Imperial Chemical Industries Ltd.

Metals Engineering Design. Edited by Oscar J. Horger. Sponsored by the Metals Engineering Handbook Board of The American Society of Mechanical Engineers. New York, McGraw-Hill Book Company, Inc., 1953. 405 pp., illus., diagrs., figs. $10.

This volume of the four-volume ASME Handbook brings together a great deal of important reference data on the design function in metals engineering, such as aids for relating considerations of material selection, design procedure, strength properties, and processing operations for good design. Forty-eight sections, contributed by authorities writing on the subjects in which they gained recognition, discuss such subjects as fatigue characteristics, wear consideration, impact, corrosion, nondestructive testing, elasticity, and theories of failure. With this tool, designers, draftsmen, and engineers in metal engineering, not only save time in searching through widely scattered literature but also find modern information on design problems presented especially from their point of view.

MATHEMATICS

Tables of Integral Transforms. Vol. 1. Based, in Part, on Notes Left by Harry Bateman and Compiled by the Staff of the Bateman Project. Prepared at the California Institute of Technology under Contract with the Office of Naval Research. New York, McGraw-Hill Book Company, Inc., 1954. 391 pp. $7.50.

Prepared as a companion to *Higher Transcendental Functions* by the same authors, this is the first of two volumes of tables of integrals involving higher transcendental functions, and is designed for the use of mathematicians, scientists, and engineers. The two volumes contain tables of all integral transforms frequently used in pure and applied mathematics and in engineering. Volume 1 contains tables of Fourier transforms (sine, cosine, and exponential), of Laplace transforms and inverse Laplace transforms, and of Mellin transforms and inverse Mellin transforms. Although prepared to be used with *Higher Transcendental Functions*, each volume of the tables may be used separately. All notations are explained in an appendix, thus making the user of the tables independent of the other volumes. Many of the integrals tabulated are new, and others, although published, are available only in scattered research papers and hard-to-obtain periodicals.

Handbook of Elliptic Integrals for Engineers and Physicists. Paul F. Byrd and Morris D. Friedman. (Grundlehren der mathematischen Wissenschaften, Band 67.) Berlin, Springer-Verlag, 1954. 355 pp., figs. DM 36.-.

This volume is a collection of over 3,000 integrals and formulas, designed to meet most practical needs, which have been presented using Legendre's and Jacobi's notations, rather than the less familiar Weierstrassian forms. Many of these formulas are substitutions and recurrence relations for evaluating additional integrals that are not explicitly written. Sufficient explanatory material and cross-references are given to permit the reader to obtain the answers he requires with a minimum of effort. The general plan of the handbook is as follows: The definitions and other basic information concerning the elliptic integrals and Jacobian elliptic functions are given first. The elliptic integrals in the various algebraic or trigonometric forms in which they are encountered in practice are expressed in terms of integrals involving Jacobian elliptic functions, which are then integrated. The remainder of the handbook is devoted to auxiliary formulas and related integrals. The book contains a bibliography of 39 references and a combined name and subject index. The authors are Aeronautical Research Scientists with NACA.

RAYTHEON MANUFACTURING CO.

RAYTHEON MISSILE & RADAR DIVISION

AERONAUTICAL AND MICROWAVE ENGINEERS

If you are qualified it will be to your advantage to investigate these openings in the Guided Missile and Airborne Radar field.

SENIOR STRUCTURES ENGINEER

Experience: 8–10 years in missile or airframe structural analysis, design, and testing.
Must be capable of supervising and planning structural design projects involving missiles, airborne electronic equipment and airframe modification.

MISSILE AND RADAR DIVISION is located in new ultra modern facility, Bedford, Mass. Geographical location, 15 miles from Boston, provides a choice of urban or rural living, together with the finest cultural, recreational and research facilities. Fine homes available. Moving expenses paid.

Please write, giving particulars concerning education and experience to

Personnel Division

RAYTHEON MANUFACTURING COMPANY

190 Willow Street, Waltham, Mass.

VELBESTOS VELBESTOS VELBEST

GASKETS

are important in an aircraft engine.
Our VELBESTOS 170-1 conforms to
AERO SPECIFICATIONS

AMS 3232F, AN-G-171, MIL-G-7021 and 33-P-22C

Samples furnished for experimental purposes.

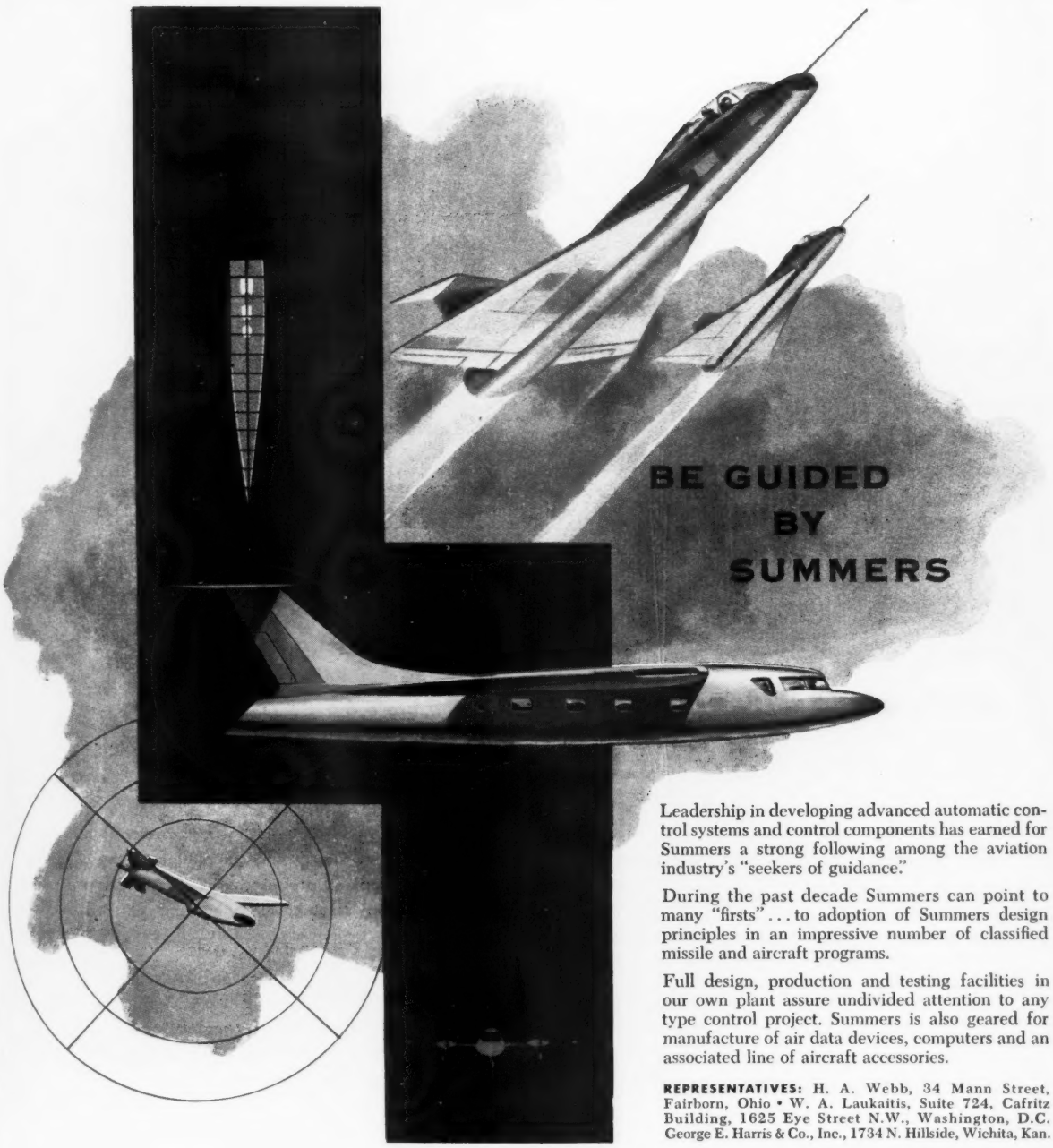
THE VELLUMOID COMPANY

WORCESTER 6, MASS.

WANTED: Woman Engineer

Challenging opportunity for woman engineer or detail design draftswoman with engineering design experience to assist Chief Engineer on long-range program designing and supervising supply of small detailed essential technical components employed in broadly applicable advanced process. Locale middle West with California possible alternative.

Aeronautical Engineering Review Box 585.



Leadership in developing advanced automatic control systems and control components has earned for Summers a strong following among the aviation industry's "seekers of guidance."

During the past decade Summers can point to many "firsts"... to adoption of Summers design principles in an impressive number of classified missile and aircraft programs.

Full design, production and testing facilities in our own plant assure undivided attention to any type control project. Summers is also geared for manufacture of air data devices, computers and an associated line of aircraft accessories.

REPRESENTATIVES: H. A. Webb, 34 Mann Street, Fairborn, Ohio • W. A. Laukaitis, Suite 724, Cafritz Building, 1625 Eye Street N.W., Washington, D.C. George E. Harris & Co., Inc., 1734 N. Hillside, Wichita, Kan.

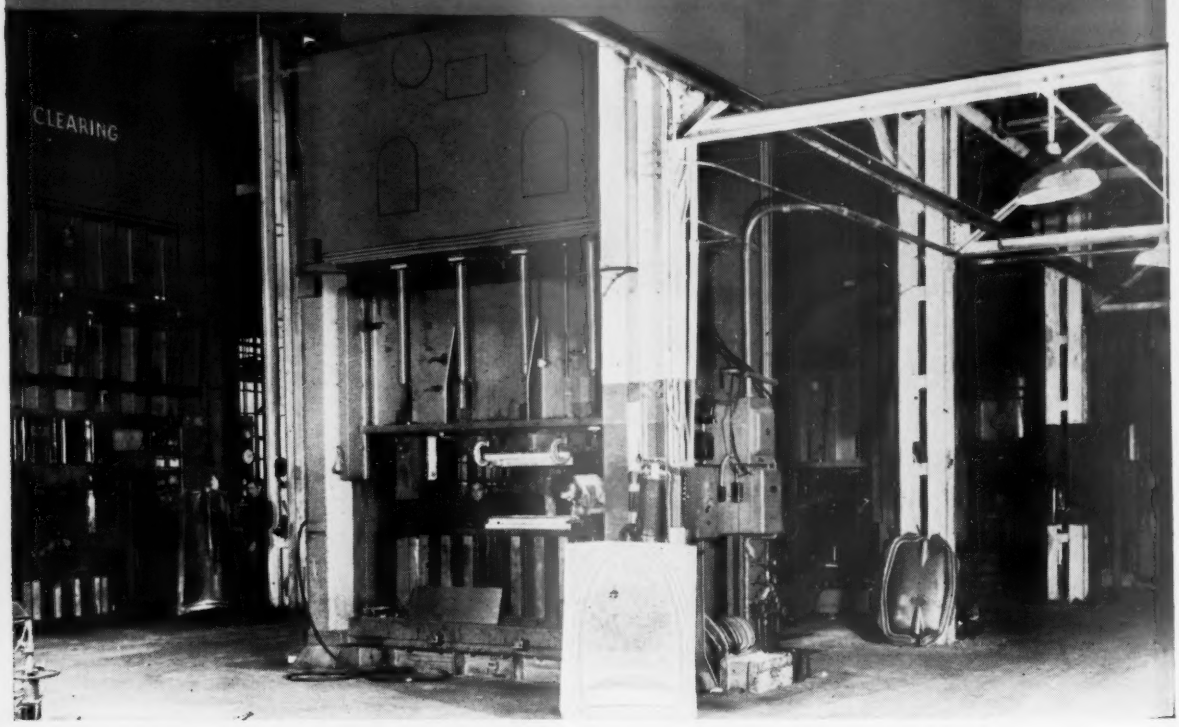
If you're beset with control problems, join the ever-growing list of companies who have asked to...

"BE GUIDED BY SUMMERS"

SUMMERS
GYROSCOPE
COMPANY
2328 BROADWAY • SANTA MONICA • CALIF.

SUMMERS DESIGNS AND PRODUCES ALL WEATHER AUTOPILOTS • RATE GYROS • FREE GYROS • VERTICAL GYROS • TORQUE-TYPE ACTUATORS • POSITIONING-TYPE ACTUATORS • GYRO SERVO ACTUATORS • INTEGRATING MOTORS • ALTITUDE CONTROLS • MAGNETIC AMPLIFIERS • FLIGHT TEST TABLES • INVERTERS • PENDULUM POTENTIOMETERS • RATE INTEGRATING DETECTORS • FREQUENCY DOUBLERS • MAGNETIC FRICTION CLUTCHES • CONTROL AMPLIFIERS • CONTROL SYSTEM TEST EQUIPMENT • SPECIAL CONTROL SYSTEM COMPONENTS • COMPLETE CONTROL SYSTEMS • RADIO RECEIVERS • RADIO TRANSMITTERS • FLIGHT COMPUTERS • CONTROL SYSTEM ANALYSIS SERVICE • ANALOG SIMULATION AND SERVICE • SUMMERS DESIGNS, DEVELOPS AND PRODUCES INSTRUMENTS IN ANY QUANTITY

FOR PROTOTYPE PARTS . . .



Allied's Allite Division Offers...

DIE-MADE SHEET METAL PARTS!

If you are following the example of a number of America's leading industries in building complete and accurate product prototypes before establishing definite manufacturing procedures, here is a time- and money-saving service which has become an important part of many such programs.

Take Allied draw and form dies for producing prototype parts . . . such dies are made of either plastic or Allite (zinc alloy) depending on the number or type of pieces required. Cost and delivery is considerably less than that of production dies, yet accuracy is comparable in every way. Upon completion of the dies, prototype stampings are produced in Allied's press equipment, then trimmed, flanged and pierced by hand.

These prototype parts are another of Allied's die and stamping services which result in a dollar savings to you. We would appreciate your inquiry, or better yet a personal visit to our Plant Four in Hillsdale, Michigan, to show you such operations.

Other Allied Products { SPECIAL COLD FORGED PARTS • STANDARD CAP SCREWS • HARDENED AND PRECISION GROUND PARTS • R-B INTERCHANGEABLE PUNCHES AND DIES

PRECISION • EXPERIENCE • DEPENDABILITY — ALLIED CORPORATION PRODUCTS

ALLIED PRODUCTS CORPORATION

DEPT. D-18 • 12655 BURT ROAD • DETROIT 23, MICH.

PLANT 1
Detroit, Mich.

PLANT 2
Detroit, Mich.

PLANT 3
Hillsdale, Mich.

PLANT 4
Hillsdale, Mich.

Personnel Opportunities

This section is for the use of individual members of the Institute seeking new connections and organizations offering employment to Aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

Wanted

Assistant to Manager—The Trane Company, a leading manufacturer of air conditioning, heating, ventilating, and heat-transfer equipment, has unusual opening for young graduate engineer. Applicant must have interest in heat-transfer engineering and sales management *plus* 2 to 5 years' experience in aircraft systems or components of systems. Excellent opportunity to advance with growing concern. Submit résumé to: The Trane Company, La Crosse, Wis. Attention: D. B. Reed.

Aeronautical or Mechanical Engineer—Graduate mechanical or aeronautical engineer to conduct experimental research in fields of fluid flow and combustion. Company is engaged in developments in welding, oxygen cutting, and use of industrial gases for metallurgical processing. This is a permanent position in a company located in north central New Jersey. Please submit complete résumé of professional and personal background. Reply will be held confidential. Address replies to: Air Reduction Research Laboratories, Murray Hill, N.J. Attention: Personnel Department.

Chief of Aerodynamics and Dynamics—Bell Aircraft Corporation, Helicopter Division located conveniently to Fort Worth and Dallas, Tex., requires an engineer-scientist to head its expanding aerodynamics and dynamics groups. The man we are seeking should have a minimum of 5 years' experience in rotary-wing aircraft or an allied technical field. He should be competent in the fields of general and rotary-wing aerodynamics, stability, performance, mechanics and vibrations analysis, and familiar with modern computational aids and methods. The position requires responsibility for the overall guidance of our work in the fields indicated. In addition, the man selected will be expected to train and develop engineers under his supervision for positions of increased responsibility. Salary commensurate with ability and qualifications. Please reply, forwarding résumé to: Harry M. Miller, Manager, Engineering Personnel, Bell Aircraft Corporation, Fort Worth, Tex.

Research Engineers—Opportunity to participate in a variety of stimulating helicopter research activities dealing with stability and control, aerodynamics, and performance. Princeton University offers good pay, pleasant surroundings, 5-day week, and 1 month vacation. Please send your résumé to: J. S. Henry, The James Forrestal Research Center, Princeton University, Princeton, N.J.

Engineers—Openings in Guided-Missile & Rocket Development Program. Need qualified personnel in the fields of engineering, mathematics, physics, chemistry, and ballistics. Opportunity for self-expression and extension of present scientific knowledge. Write or send application of Standard Form 57, which can be obtained at your Post Office, to Commanding General, Redstone Arsenal, Huntsville, Ala. Attention: Luther Adams, Civilian Personnel Division.

Engineers—The Special Devices Center, Port Washington, N.Y., a research and development activity of the Navy, has vacancies for qualified aeronautical and electronic engineers. The Federal Civil Service requirements, the experience desired, and the entrance salaries are as follows: **Aeronautical Engineer**—$5,940 per year. Requirements: An engineering degree plus 2½ years of professional engineering experience, of which at least 6 months must have been spent in aeronautical engineering. Experience in aircraft instrumentation and analog computing equipment, including servo systems is particularly desired. **Electronic Engineer**—$5,940 per year. Requirements: An engineering degree plus 2½ years of professional engineering experience, of which at least 6 months must have been in electronics. Experience with radar, sonar, or servomechanisms and in field testing, evaluation, and modification is particularly desired. Interested individuals should forward Standard Form 57, Application for Federal Employment, to the Industrial Relations Officer, Special Devices Center, Port Washington, N.Y.

Professor—To teach undergraduate courses in aerodynamics and propulsion, design and supervise construction of teaching and research laboratory facilities, and do part-time research. Advanced degree and industrial experience desirable. Salary and rank dependent upon qualifications. Address inquiries with complete personal data and photograph to: Head, Department of Aeronautical Engineering, Alabama Polytechnic Institute, Auburn, Ala.

Instrumentation Engineer—The Department of Aeronautical Engineering, Princeton University, has a position available for an Instrumentation Engineer to work at faculty level on advanced instrumentation techniques in conjunction with jet- and rocket-propulsion research. Applicant should have a Masters Degree or equivalent experience in electronic instrumentation. Applications should be sent to Engineering Manager, Jet Propulsion Research Program, Department of Aeronautical Engineering, Forrestal Research Center, Princeton University, Princeton, N.J.

Available

582. Engineer—B.S. in Engineering and Business Administration. Presently completing M.S. in Applied Mathematics (evenings). Age 28. Four years' experience in aircraft and mechanical design and 1 year's experience in aircraft engineering administration. Desires responsible position in engineering or engineering administration on East Coast.

580. Aeronautical Engineer—B.S. in Aero. E. plus night and summer school graduate study. Over 10 years' responsible aeronautical engineering experience including 4 years as aeronautical research scientist with NACA; further work in research, design, and development of aircraft propulsion components and test facility design and operation with several months in nuclear engineering. Considerable technical report writing and editing and supervisory experience. Present position in gas-turbine design and development. Present salary approximately $8,000 per year for 40-hour week schedule. Desires engineering position with administrative responsibility utilizing aerodynamic or thermodynamic experience in development, design, or manufacturing in Midwest. Prefer Iowa, Missouri, Illinois, or Nebraska location. Available May 1.

579. Aeronautical Engineer—B.Ae.S., M.S., Professional Engineer. Four years' experience in supersonic wind-tunnel testing; 1 year in supersonic wind-tunnel design. Work has included heat transfer and thermodynamics of propulsion. Desires position in the field of basic or applied supersonic research. Complete résumé of experience and published reports supplied upon request.

578. Administrative—B.S. in Aeronautical Engineering plus 5½ years' experience as Stress Analyst, Project Engineer, Chief Draftsman, and Chief Administrative Engineer. Desires an administrative- or supervisory-type position. Résumé furnished on request. Age 32.

577. Engineer - Administrator—Regular Air Force Major; Graduate of U.S. Military Academy, USAF Institute of Technology, Princeton University (M.S.Aero.E.). Air Force research and development experience includes that of test pilot, project engineer, flight research engineer, operations and plans, research administrator, and development planning. USAF Senior Pilot and commercial and instrument ratings. Desires position with responsibility and opportunity for advancement in industry.

576. Engineering Designer—B.S. Aeronautical Engineering. Conscientious young engineer with 3½ years' experience in rotary-wing design seeks an interesting and challenging position with a progressive organization. Experienced in airframe design and layout and electronic equipment installation. Also good knowledge of stress analysis and some technical report writing.

575. Aircraft Engineer (British)—Age 36. A.R.Ae.S., A.M.S.L.A.E., MIAS. Eighteen years' aircraft experience includes: 5 years of

The number preceding the notice represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

Are you one of a select group of aerodynamicists sincerely interested in boundary layer control projects? The Aircraft Division of Fairchild offers a genuine creative opportunity to such men.

Reconnaisance aircraft . . . jet fighters . . . jet bombers and transports . . . as well as engineering advances on the world-renowned C-119 Flying Boxcar and soon-to-be-produced C-123 Assault Transport are coming from Fairchild. Diversified, stimulating assignments like these increase the inventive challenge to Fairchild's team of qualified aerodynamicists.

Gracious country living only minutes away from urban Baltimore or Washington . . . paid pension plan . . . an excellent salary with paid vacations . . . an ideal working environment . . . generous health, hospitalization and life insurance . . . and the many other benefits of a progressive company add to the pleasure of working with Fairchild.

You'll be investing wisely in a secure future if you take time today to write to Walter Tydon, Chief Engineer, outlining your qualifications. Your correspondence will be kept in complete confidence, of course.

☆ **BOUNDARY LAYER CONTROL**

ENGINE AND AIRPLANE CORPORATION
FAIRCHILD
Aircraft Division
HAGERSTOWN, MARYLAND

A.I.D. inspection on production, experimental ground and flight testing engines, propellers, and power plants. Three years in complete charge of aircraft repair and overhaul shops—British and American naval aircraft. Eight years as Technical Officer and Aircraft Surveyor to group of insurance companies dealing with accident surveys, repair negotiations, liaison, and outside representation. Extensive knowledge of aviation insurance, international air law, regulations, and organizations. Permanently commissioned as Lt. Commander, Royal Naval Volunteer Reserve. Seeking position where past experience may be fully utilized, preferably in or adjacent to Tropics (stationed in India during war). Full details will be air mailed immediately upon receipt of application.

574. Executive Engineer—B.S. in Ae.E. Age 36. Registered Professional Engineer. Fifteen years' experience in industry and Government as structures engineer and supervisor. Presently Chief of Structural Criteria, Air Force Development Center. Experienced in engineering supervision, contract administration, budgeting, research, and general management. Desires position as executive or staff engineer or engineering manager in organization with future possibility at management level.

573. Engineer—B.S., 1940. Extensive experience with multiengined aircraft, mechanical and structural. Two years in research and development of gas turbines. Held AEDO billet with BuAer for 4 years. Six thousand hours multiengined logged. Desires connection with manufacturer as engineer preferably in development, with possibility of some piloting. Age 35.

572. Professor—Presently supervising structural analysis program of large aircraft manufacturer. Available to teach in September. Extensive teaching and industrial experience in aircraft structures, design and helicopter aerodynamics. B.Ae.E., M.S., P.E. Please furnish outline of position available and salary schedule.

571. Advertising & Public Relations Manager—B.S. in Engrg./Business Admin., MBA in Marketing. Age 34. Ten years' progressive experience in all phases of industrial promotion: program planning, budgeting and administration, agency and media liaison, space and promotional copy planning, writing and editing, pamphlets and brochures, and technical publicity. Press, industry, and Government relations. Licensed pilot, mechanic, and radio operator with background in aviation equipment, radio, electronics, and air transport. Desires position offering greater responsibilities and opportunity for advancement.

570. Mechanical Engineer—B.S. Degree. Thirteen years of varied experience in the development of aircraft and missile propulsion systems and in the development of facilities and instrumentation for testing propulsion systems. This includes 3 years of supervisory and administrative experience. Would like to associate with a progressive organization in a position that will utilize past engineering experience but will also provide an outlet to utilize a strong interest and training in general management work. Résumé on request. All inquiries will be answered.

569. Gas Turbine Engineer—B.Sc. Age 30. Six years' experience in experimental research, aerodynamic design, and performance analysis of British jets and turboprops. Presently in United States. Seeks responsible post in industry or university research center. Complete résumé and list of publications on request.

Recent technical advances at **HUGHES** *have created new openings with exceptional opportunities for full use of technical judgment and inventive ability.*

staff engineer...
ELECTRONICS

With extensive background and qualifications for assuming responsibility for development of automatic guidance systems utilizing radar, infrared or sonar.

aerodynamicist

With experience in supersonic aerodynamics and the ability to evaluate the performance and stability of supersonic aircraft.

hydrodynamicist

With experience in design of hydrodynamic features of underwater weapons and the ability to evaluate the performance and stability of such missiles.

ALL REPLIES
HELD IN
STRICT CONFIDENCE

Hughes

TOOL COMPANY
Aircraft Division
11940 JEFFERSON BLVD.
Culver City, California

If you meet the above qualifications, and wish to locate in Southern California, you are invited to write for further information regarding these positions. Include your resume, and a telephone number where you may be reached for an interview.

SALARY COMMENSURATE
WITH QUALIFICATIONS

ENGINEERS

The APPLIED PHYSICS LABORATORY OF THE JOHNS HOPKINS UNIVERSITY offers an exceptional opportunity for professional advancement in a well-established laboratory with a reputation for the encouragement of individual responsibility and self-direction. Our program of

GUIDED MISSILE RESEARCH AND DEVELOPMENT

provides such an opportunity for men qualified in:

SUPERSONIC MISSILE DESIGN
WIND TUNNEL TESTS AND DATA ANALYSIS
RAMJET DESIGN AND ANALYSIS
MISSILE SYSTEMS DEVELOPMENT
FLIGHT TEST PROPOSALS AND DATA ANALYSIS

Please send your résumé to

Glover B. Mayfield
APPLIED PHYSICS LABORATORY
THE JOHNS HOPKINS UNIVERSITY
8621 Georgia Avenue
Silver Spring, Maryland

An Opportunity

is offered for intelligent, imaginative engineers and scientists to join the staff of a progressive and self-sustaining, university-affiliated research and development laboratory. We are desirous of expanding our permanent staff in such fields as design studies of advanced supersonic aircraft, analytical and experimental studies of aeroelasticity, helicopters, aircraft structures, control and stability, large scale wind tunnel testing, and in various other applied research fields of aeronautics.

Salary structure and benefit programs are on a par with industry. In addition, there are many tangible advantages, such as our self-sponsored internal research policy, of interest to men with ingenuity and initiative.

CORNELL AERONAUTICAL LABORATORY, INC.
BUFFALO 21, NEW YORK

Grumman

ENGINEERS

needed to work on new

"Grumman Cat"

Grumman, nearing its 25th Anniversary, needs engineers to work on its new experimental light-weight Naval fighter, plus other jet fighters, anti-sub planes, and amphibians. Grumman has openings for experienced aircraft engineers, and recent engineering graduates.

LAYOUT DESIGNERS AND DRAFTSMEN
Airframe Structures
Equipment Insfallation
Detail Drafting

FLIGHT TESTING
Planners
Analysts
Computers

HYDRAULICS
Systems Design
Testing

STRUCTURES
Stress Analysis
Static Testing
Applied Loads

Send resumés to Engineering Personnel Dept. Interviews at Employment office.

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE • LONG ISLAND • NEW YORK

CORPORATE MEMBERS

OF THE

INSTITUTE OF THE AERONAUTICAL SCIENCES

ACADEMY OF AERONAUTICS, INC.
ADAMS RITE MANUFACTURING COMPANY
AEROJET-GENERAL CORPORATION, SUBSIDIARY OF THE GENERAL TIRE & RUBBER COMPANY
AEROLAB DEVELOPMENT COMPANY
AERONCA MANUFACTURING CORPORATION
AEROQUIP CORPORATION
AGAWAM AIRCRAFT PRODUCTS, INC.
AIR ASSOCIATES, INC.
AIRBORNE ACCESSORIES CORPORATION
AIRBORNE INSTRUMENTS LABORATORY, INC.
AIRCRAFT RADIO CORPORATION
AIRESEARCH MANUFACTURING COMPANY, DIVISION OF THE GARRETT CORPORATION
ALLIS-CHALMERS MANUFACTURING COMPANY
ALLISON DIVISION, GENERAL MOTORS CORPORATION
ALUMINUM COMPANY OF AMERICA
AMERICAN AIRLINES, INC.
AMERICAN BOSCH CORPORATION
AMERICAN HELICOPTER DIVISION OF FAIRCHILD ENGINE AND AIRPLANE CORPORATION
AMERICAN PHENOLIC CORPORATION
AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL CORPORATION
ANDERSON, GREENWOOD & COMPANY
ARDE ASSOCIATES
ASSOCIATED AVIATION UNDERWRITERS
AVIATION ENGINEERING DIVISION, AVIEN-KNICKERBOCKER, INC.
BAKER STEEL & TUBE COMPANY
BEECH AIRCRAFT CORPORATION
BELL AIRCRAFT CORPORATION
BENDIX AVIATION CORPORATION
- BENDIX INTERNATIONAL DIVISION
- BENDIX PRODUCTS DIVISION
- BENDIX RADIO DIVISION
- ECLIPSE-PIONEER DIVISION
- FRIEZ INSTRUMENT DIVISION
- PACIFIC DIVISION
- SCINTILLA DIVISION

THE BG CORPORATION
BOEING AIRPLANE COMPANY
- SEATTLE DIVISION
- WICHITA DIVISION

BOOZ, ALLEN & HAMILTON
BRANDT MANUFACTURING COMPANY
BREEZE CORPORATIONS, INC.
BRISTOL AEROPLANE ENGINES (EASTERN) LIMITED
BROOKS AND PERKINS, INC.
CAL-AERO TECHNICAL INSTITUTE
CALIFORNIA PANEL & VENEER COMPANY
CANADAIR LIMITED
THE CESSNA AIRCRAFT COMPANY
THE CHASE NATIONAL BANK OF THE CITY OF NEW YORK
CIBA COMPANY, INC.
THE CLEVELAND PNEUMATIC TOOL COMPANY
CLIFFORD MANUFACTURING COMPANY, DIVISION OF STANDARD-THOMSON CORPORATION
CONSOLIDATED VULTEE AIRCRAFT CORPORATION
- FORT WORTH DIVISION
- SAN DIEGO DIVISION

CONSULTANTS & DESIGNERS, INC.
CONTINENTAL MOTORS CORPORATION
COOPER PRECISION PRODUCTS
CORNELL AERONAUTICAL LABORATORY, INC.
CURTISS-WRIGHT CORPORATION
- ELECTRONICS DIVISION
- MARQUETTE METAL PRODUCTS COMPANY
- PROPELLER DIVISION
- WRIGHT AERONAUTICAL DIVISION
- DECKER AVIATION CORPORATION

DOAK AIRCRAFT COMPANY, INC.
DOELCAM CORPORATION
DOUGLAS AIRCRAFT COMPANY, INC.
- EL SEGUNDO PLANT
- LONG BEACH PLANT
- SANTA MONICA PLANT
- TULSA DIVISION

THE DOW CHEMICAL COMPANY, MAGNESIUM DEPARTMENT
DZUS FASTENER COMPANY, INC.
EASTERN AIR LINES, INC.
EATON MANUFACTURING COMPANY
EDO CORPORATION
ELASTIC STOP NUT CORPORATION OF AMERICA
ELECTROL INCORPORATED
ESSO STANDARD OIL COMPANY
ETHYL CORPORATION
FAIRCHILD CAMERA AND INSTRUMENT CORPORATION
- FAIRCHILD AERIAL SURVEYS, INC.

FAIRCHILD ENGINE AND AIRPLANE CORPORATION
- FAIRCHILD AIRCRAFT DIVISION
- FAIRCHILD ENGINE DIVISION
- FAIRCHILD GUIDED MISSILES DIVISION
- STRATOS DIVISION

FEDERAL TELECOMMUNICATION LABORATORIES, INC.
FIRESTONE TIRE & RUBBER COMPANY
FLETCHER AVIATION CORPORATION
FLIGHT REFUELING, INC.
FLIGHT SAFETY FOUNDATION, INC.
GENERAL ELECTRIC COMPANY
- AERONAUTIC & ORDNANCE SYSTEMS DIVISION
- AIRCRAFT GAS TURBINE DIVISION
- AVIATION DIVISIONS

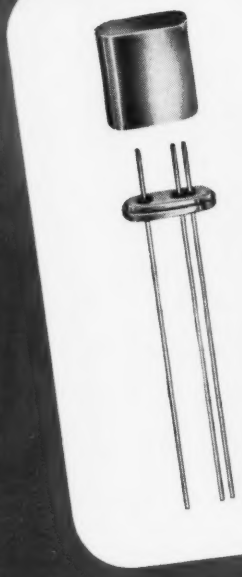
GENERAL PRECISION EQUIPMENT CORPORATION
G. M. GIANNINI & CO., INC.
THE B. F. GOODRICH COMPANY
THE GOODYEAR TIRE & RUBBER COMPANY
GRUMMAN AIRCRAFT ENGINEERING CORPORATION
HARVEY MACHINE COMPANY, INC.
ROBERT HEWITT ASSOCIATES
INDUSTRIAL SOUND CONTROL, INC.
INSURANCE COMPANY OF NORTH AMERICA COMPANIES
THE INTERNATIONAL NICKEL COMPANY, INC.
JACK & HEINTZ, INC.
JOHNS-MANVILLE SALES CORPORATION
CORYDON M. JOHNSON COMPANY, INC.
EARLE M. JORGENSEN COMPANY
WALTER KIDDE & COMPANY, INC.
KOLLSMAN INSTRUMENT CORPORATION
LAVELLE AIRCRAFT CORPORATION
LEAR INCORPORATED
THE LIQUIDOMETER CORPORATION
LOCKHEED AIRCRAFT CORPORATION
- BURBANK DIVISION
- GEORGIA DIVISION

LOEWY CONSTRUCTION COMPANY, INC.
LONGINES-WITTNAUER WATCH COMPANY, INC.
LONGREN AIRCRAFT COMPANY,
MARQUARDT AIRCRAFT COMPANY
THE GLENN L. MARTIN COMPANY
McDONNELL AIRCRAFT CORPORATION
MELETRON CORPORATION
MINNEAPOLIS-HONEYWELL REGULATOR COMPANY AERONAUTICAL DIVISION
NATIONAL CREDIT OFFICE, INC.
NORTH AMERICAN AVIATION, INC.
NORTHROP AIRCRAFT, INC.
PAN AMERICAN WORLD AIRWAYS, INC.
THE PARKER APPLIANCE COMPANY
PESCO PRODUCTS DIVISION, BORG-WARNER CORPORATION
PHILLIPS PETROLEUM COMPANY
PIASECKI HELICOPTER CORPORATION
THE PURE OIL COMPANY
RADIOPLANE COMPANY
J. B. REA COMPANY, INC.
REACTION MOTORS, INC.
REPUBLIC AVIATION CORPORATION
E. V. ROBERTS AND ASSOCIATES
A. V. ROE CANADA LIMITED
JOHN A. ROEBLING'S SONS CORPORATION
ROHR AIRCRAFT CORPORATION
PAUL ROSENBERG ASSOCIATES
RYAN AERONAUTICAL COMPANY
SCHRILLO AERO TOOL ENGINEERING COMPANY
SEABOARD & WESTERN AIRLINES, INC.
SHELL OIL COMPANY
SIMMONDS AEROCESSORIES, INC.
SOCONY-VACUUM OIL COMPANY, INC.
SOLAR AIRCRAFT COMPANY
R. DIXON SPEAS
SPERRY GYROSCOPE COMPANY, DIVISION OF THE SPERRY CORPORATION
STANDARD OIL COMPANY OF CALIFORNIA
STANDARD OIL COMPANY (INDIANA)
THE STEEL PRODUCTS ENGINEERING COMPANY
STROUKOFF AIRCRAFT CORPORATION
STURGESS, INC.
SUMMERS GYROSCOPE COMPANY
THE H. I. THOMPSON FIBER GLASS COMPANY
THOMPSON PRODUCTS, INC.
TOOLKO ENGINEERING COMPANY
TRANS WORLD AIRLINES, INC.
TURBO PRODUCTS, INC.
UNION CARBIDE AND CARBON CORPORATION
- BAKELITE COMPANY
- ELECTRO METALLURGICAL COMPANY
- HAYNES STELLITE COMPANY
- LINDE AIR PRODUCTS COMPANY
- NATIONAL CARBON COMPANY

UNITED AIR LINES, INC.
UNITED AIRCRAFT CORPORATION
- HAMILTON STANDARD DIVISION
- PRATT & WHITNEY AIRCRAFT DIVISION
- SIKORSKY AIRCRAFT DIVISION
- UNITED AIRCRAFT EXPORT CORPORATION
- UNITED AIRCRAFT SERVICE CORPORATION

UNITED STATES AVIATION UNDERWRITERS, INC.
UNITED STATES RUBBER COMPANY
VARD INC.
VICKERS, INC.
CHANCE VOUGHT AIRCRAFT, INC.
WESTERN GEAR WORKS
WESTINGHOUSE ELECTRIC CORPORATION
- AIR ARM DIVISION
- AVIATION GAS TURBINE DIVISION
- INDUSTRIAL ELECTRONICS DIVISION
- SMALL MOTOR DIVISION

WESTON ELECTRICAL INSTRUMENT CORPORATION
WYMAN-GORDON COMPANY
YOUNG RADIATOR COMPANY

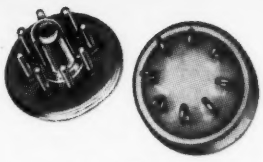


Glass to Metal Vacuum Seals

Constantin's latest achievement —

Glass to metal vacuum sealed transistor mounts that provide complete protection from moisture, dust, varying heat conditions and shock. Germanium can be sealed in vacuum or inert gas. A special soldering moat is a feature for easy assembly. Leads are spaced to fit standard sub-miniature sockets and can be supplied 1½" long for soldering directly to circuits.

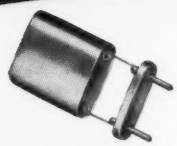
AN CONNECTORS
Precision construction throughout. Glass to metal vacuum seal assures protection against varying atmospheric conditions. Available in most JAN specifications.



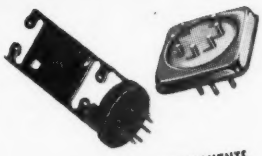
MULTIPLE HEADERS
Plug and standard types. Built to withstand thermal shock and provide stabilized atmospheres. Available in various configurations.

SINGLE TERMINALS AND END SEALS
Terminals available in all combinations of hooks, eyes, tubes, and pierced flats. Test rated from 1,000 to 15,000 volts R.M.S. and 5 to 25 amps. Single end seals available in various sizes for items requiring stabilized atmospheres.

HIGH COMPRESSION SEALS AVAILABLE



CRYSTAL HOLDERS
The highly rigid metal bridge unit is designed to withstand severe strain without deformation. The one piece sealing medium minimizes stresses on the pins which could produce internal strain



CUSTOM ENGINEERED COMPONENTS
Constantin is capable of manufacturing any glass to metal sealed requirement. Free engineering assistance given upon request.

Hot tin plating at 530°F. facilitates easy soldering, thereby eliminating rejections during assembly. Special plating supplied on request. Glass to Kovar seals, made under Westinghouse patents, are ideal for use in extreme temperatures. Blueprints can be furnished upon request.

VACUUM COATING EQUIPMENT

COMBINATION BASE AND FINAL FREQUENCY CALIBRATION PLATING MACHINE FOR QUARTZ CRYSTALS — Model 3
Precision equipment designed to deposit micro-tolerance film of metal (gold, silver, platinum, etc.) on quartz crystal oscillator plates. Operates at vacuum of less than 1/100 micron.

MANIFOLD TYPE FINAL FREQUENCY CALIBRATION UNIT TYPE FFO — Model 4
Unit is engineered to calibrate one crystal every 15 seconds with vacuum of less than ½ micron. May be bench mounted in multiples.

L. L. Constantin & Co.

MANUFACTURING ENGINEERS

Rt. 46 and Franklin Avenue Lodi, N. J.

A completely self-contained company equipped with the most modern machine shop and facilities for die construction, stampings, bending, and wire cutting. Also a Glass Department capable of compounding, tableting and sintering. Latest ovens and furnaces for fusing. Advanced plating techniques. Skilled Engineering. These combined features enable us to provide a TOP QUALITY product completely manufactured on our premises. Product or sample delivery can be made almost immediately.

Index to

A

AC Spark Plug Division, General Motors Corporation 137
★Adel Division, General Metals Corporation 146
Aerojet-General Corporation, Subsidiary of General Tire & Rubber Company 42
Aeronautical Engineering Catalog 155, 171, 180
Aeronautical Engineering Review 171
★Airborne Accessories Corporation 35
AiResearch Manufacturing Company 172
Allied Products Corporation 184
Allison Division, General Motors Corporation 18
Allmetal Screw Products Company, Inc. 113
★American Chemical Paint Company 12
★American Phenolic Corporation 143
Arma Corporation ..... Inside Back Cover

B

B. H. Aircraft Company Inc. 112
B & H Instrument Company, Inc. 123
Beckman Instruments, Inc., Helipot Corporation 156
Bell Aircraft Corporation 166
Bendix Aviation Corporation
★Bendix Products Division 163
Pacific Division 16, 17
Red Bank Division 117
★Scintilla Division 139, 171
★BG Corporation, The 114
Bower Roller Bearing Company 22
Bristol Engineering Corporation 14

C

★Cannon Electric Company 121
★Chain Belt Company, Shafer Bearing Division 159
Ciba Company Inc., Plastics Division 127
Clifford Manufacturing Company Division, Standard-Thomson Corporation 44
★Collins Radio Company 24, 25
Consolidated Vultee Aircraft Corporation ..... Back Cover, 111
L. L. Constantin & Company 189
Cooper Precision Products 165
Cornell Aeronautical Laboratory, Inc. 187
Crane Company, Hydro-Aire Inc. Subsidiary 177

D

Dale Products, Inc. 124
Doelcam Corporation 192
Douglas Aircraft Company, Inc. 30
Dow Chemical Company, The, Magnesium Sales Department 36, 37
★Dow Corning Corporation 153, 154
Dynamic Air Engineering Inc. 123

E

Eagle Pencil Company 147
★Eastern Industries, Inc. 21
★Electrical Engineering and Manufacturing Corporation 19
★Electrol Incorporated 122
Electronic Specialty Company, Contract Division 109

F

Fairchild Engine and Airplane Corporation
★Fairchild Aircraft Division 15, 186
Fairchild Guided Missiles Division 48
★Fenwal Incorporated 38
★Flexonics Corporation, Aircraft Division 26
★Foote Bros. Gear and Machine Corporation 135
Ford Instrument Company, Division of The Sperry Corporation 5

G

General Electric Company 46, 47
★General Metals Corporation, Adel Division 146
General Motors Corporation
AC Spark Plug Division 137
Allison Division 18
Harrison Radiator Division 125
New Departure Division 149
General Tire & Rubber Company, Aerojet-General Corporation Subsidiary Division 42
★G. M. Giannini & Co., Inc., Laboratory Apparatus Division 161
B.F. Goodrich Company, The, Aeronautical Sales 105
Goodyear Aircraft Corporation 13
Goodyear Tire & Rubber Company, Inc., The, Aviation Products Division 1
Grumman Aircraft Engineering Corporation 28, 29, 187
★Gyromechanisms, Inc. 124, 155

H

Harrison Radiator Division, General Motors Corporation 125
Helipot Corporation, Division of Beckman Instruments, Inc. 156
Hufford Machine Works, Inc., Electronics Division. 129
Hughes Tool Company, Aircraft Division 187
Hydro-Aire Inc., Subsidiary of Crane Company 177

I

Imperial Tracing Cloth, Keuffel & Esser Company 156
Indiana Gear Works, Inc. 45
International Rectifier Corporation 32

J

Johns Hopkins University, The 187
★Johns-Manville 33

K

Kearfott Company, Inc. 128
Ketay Manufacturing Corporation 119, 120
Walter Kidde & Company, Inc. 40

L

★Lamb Electric Company, The 150
★Lear, Incorporated 140
★LearCal Division 160
★Liquidometer Corporation, The 131
Lockheed Aircraft Corporation 167, 174
Lord Manufacturing Company 43

Advertisers

M

Manning, Maxwell & Moore, Inc., Aircraft Products Division 175
Glenn L. Martin Company, The 23, 168
★McCulloch Motors Corporation, Rhodes Lewis Company Subsidiary 6
★Meletron Corporation 116
Wm. Miller Instruments, Inc. 136
Motoresearch Company 109
Mueller Electric Company 114

N

National-Standard Company 4
New Departure Division, General Motors Corporation 149
Northrop Aircraft, Inc., Radioplane Company Subsidiary 20

P

★Pacific Airmotive Corporation, Aero-Pneumatics Division 173
Pacific Division, Bendix Aviation Corporation 16, 17
Parker Aircraft Company, Subsidiary of The Parker Appliance Company 10, 11
Pickering & Company, Inc. 114

R

Radio Corporation of America 157, 164
Radioplane Company, Subsidiary of Northrop Aircraft, Inc. 20
Raytheon Manufacturing Company 182
Red Bank Division, Bendix Aviation Corporation 117
Republic Aviation Corporation, Guided Missiles Division 170
★Research Development Manufacture, Inc. 8
★Rhodes Lewis Company, Subsidiary of McCulloch Motors Corporation 6
★Rohr Aircraft Corporation 7
★Ryan Aeronautical Company 145

S

Sanborn Company, Industrial Division 9
★Scintilla Division, Bendix Aviation Corporation 139, 171
★Shafer Bearing Division, Chain Belt Company 159
Shell Chemical Corporation 27
Skinner Electric Valve Division, The Skinner Chuck Company 109
Solar Aircraft Company 174
The Sperry Corporation
Ford Instrument Division 5
★Sperry Gyroscope Company Division 133
★Vickers Incorporated Division 178
★Standard Pressed Steel Company, Aircraft Products Division 41
Standard-Thomson Corporation, Clifford Manufacturing Company Division 44
★F. W. Stewart Mfg. Corporation 148
★Summers Gyroscope Company 183
Sundstrand Machine Tool Company ..... Inside Front Cover
Surface Combustion Corporation, Aircraft-Automotive Division 106, 107

T

Temco Aircraft Corporation 34
Topp Industries, Inc. 161

U

United Manufacturing Company 109
United States Aviation Underwriters Inc. 155

V

Vellumoid Company, The 182
★Vickers Incorporated Division, The Sperry Corporation 178

W

Waldes Kohinoor, Inc. 169
Waterman Products Company, Inc. 115
Weber Aircraft Corporation 151
★Western Gear Works 181
Westinghouse Electric Corporation, Air Arm Division 99–102
★Weston Electrical Instrument Corporation 31
Winchester Electronics, Inc. 39

★ *Specifications and further information on the aircraft products of these companies will be found in the* **1954 AERONAUTICAL ENGINEERING CATALOG**

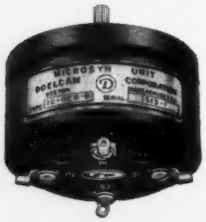
The only publication of its kind devoted exclusively to the aircraft industry, this CATALOG serves as a valuable buyers' and reference guide to sources and specifications on aircraft materials, parts, and accessories. It is distributed annually to Chief Engineers, Designers, Production Heads, and Purchasing Departments of all leading Aircraft, Aircraft Engine, Instrument, Accessory, and Aircraft Parts Manufacturers; Air Transport Companies; Army, Navy, and Governmental Agencies; Research Organizations; Engineering Libraries; etc.

Published Annually by

INSTITUTE OF THE AERONAUTICAL SCIENCES

2 East 64th Street New York 21, N.Y.

Write for Bulletin MP2



MICROSYN POSITION INDICATORS linearly transform an angular displacement into an electrical signal for application in fire control systems and gyro instrumentation.

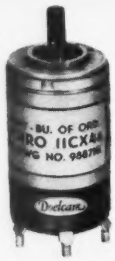
Resolution to less than 1/100 of 1 degree

Write for Bulletin KG2

TYPE K RATE GYROS measure absolute angular rates about any one axis for flight test evaluation or control of aircraft. They are also proven components for use in control and homing systems in guided missiles.

Accurate to ⅛ of 1 % of full scale

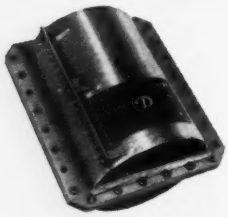
Write for Bulletin S2



SYNCHROS size 11 (1.062" O.D.) 115 volt, 400 cps Control Transmitters and Transformers are approved standard military components (MIL-S-16892). Other sizes and types are also available.

Average electrical error — 5 minutes of arc

Write for Bulletin CFG2



CAGEABLE FREE GYROS are designed expressly for guided missile applications. They are available with either Synchro or Potentiometer type pickoffs.

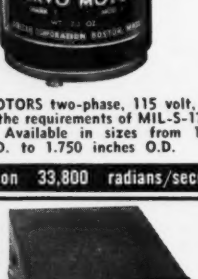
Drift is less than ¼ degree/minute

Write for Bulletin SM2

SERVO MOTORS two-phase, 115 volt, 400 cps fulfill the requirements of MIL-S-17087 (BuOrd). Available in sizes from 1.062 inches O.D. to 1.750 inches O.D.

Acceleration 33,800 radians/second²

Write for Bulletin VF2



VFDD POWER SUPPLY – DEMODULATOR serves as a link between sensing instruments and recording equipment. With the DOELCAM Type K Rate Gyros it comprises a complete system for flight evaluation of military aircraft.

Voltage-regulated to 1 %
Frequency stabilized to 0.2 %
Demodulators linear to 1 %

Doelcam

Master-precision

MILITARY COMPONENTS

IN EVIDENCE of the exceptional performance of DOELCAM *Master-precision* components, a measure of accuracy is presented with each unit illustrated. Tested and perfected for military use, DOELCAM electromechanical instruments for measurement and control are now standard components in automatic pilots, guided missiles, airborne instrumentation and fire control computers. DOELCAM'S expanded manufacturing facilities now make it possible to offer these *Master-precision* components in production quantities for military applications. An outstanding engineering staff with broad experience in the field of instrumentation is available for assistance on your specific problem. For more detailed information — *write for bulletins.*

Doelcam CORPORATION

SOLDIERS FIELD ROAD, BOSTON 35, MASS.
West Coast Office: 304 Tejon Pl., Palos Verdes, Calif.

Instruments for Measurement and Control

Synchros • Gyros • Servos • Microsyns • Servo Motors

AERONAUTICAL REVIEWS

New Products and Product Literature of interest to IAS members

▼▼▼▼

AIRCRAFT MATERIALS & PROCESSES

Room Temperature Vulcanizing Silastic. This silicone rubber develops high- and low-temperature stability, water repellency, and chemical resistance within 24 hours after application. **Dow Corning Corp., Midland, Mich.**

"Eccofoam" Plastic Material. A low-density, rigid, unicellular, thermosetting plastic foam material with a wide range of bulk densities. **Emerson & Cuming, Inc., 869 Washington St., Canton, Mass.**

Thermosetting Material. "Stycast TPM" a low-loss, low dielectric constant, casting resin usable over an extremely wide temperature range. **Emerson & Cuming, Inc., 869 Washington St., Canton, Mass.**

Solid Film Lubricant. Developed for operational temperatures of −60°F. to +1,000°F. **Everlube Corp., 6940 Farmdale Ave., North Hollywood, Calif.**

"Teflon" Pressure Sensitive Adhesive. "Flexrock #80" adhesive for bonding "Teflon" to itself and other materials and metals. **Flexrock Co., Packing Div., 3604-J Filbert St., Philadelphia 1, Pa.**

Soft Magnetic Core Material. "Ferramic Q," for antenna rods, filter inductances, loading coils, RF coils, and all applications requiring high performance at frequencies up to 30 mc. **General Ceramics & Steatite Corp., Keasbey, N.J.**

Unalloyed Titanium. Four-page folder describes the properties of, and recommended techniques for, fabricating and forming titanium sheet. **Mallory-Sharon Titanium Corp., Niles, Ohio.**

"Sicon" Heat-Resisting Coating. This silicone-base heat-resistant finish protects jet-engine parts. **Midland Industrial Finishes Co., Waukegan, Ill.**

EC-1209 Extruded Rubber-Based Sealer. Applied in the form of a flexible rubber strip, this sealer cures and expands $2\frac{1}{4}$ times when heated to form a positive, uniform, gasket-like material between metal surfaces. **Minnesota Mining & Mfg. Co., Adhesives & Coatings Div., 423 Piquette Ave., Detroit 2, Mich.**

"Permacel" 12 Acoustimat Sound Damping Tape. A pressure-sensitive tape applied to the interior fuselage panels, creating a sound barrier against noises caused by vibration. **Permacel Tape Corp., New Brunswick, N.J.**

Laminate of Copper to Polyester Glass-Mat Sheet. "Estoglas," a base for etched circuits in electronic applications. **Plastilight, Inc., 481 Canal St., Stamford, Conn.**

Corrosion-Resistant Filter Medium. Brochure No. T-103 describes porous "Kel-F." **Porous Plastic Filter Co., Glen Cove, N.Y.**

"Zorlok," Mastic Nut Lock. This thread-sealing compound eliminates lock washers and special lock nuts. **Presstite Engineering Co., 3798 Chouteau Ave., St. Louis 10, Mo.**

Asbestos Products for Aircraft. Descriptive brochure No. 4920. **Raybestos-Manhattan, Inc., Packing Div., Manheim, Pa.**

Breathable Vinyl Upholstery. For use in aircraft seats. **U.S. Rubber Co., Rockefeller Center, N.Y.C.**

AIRCRAFT PARTS & EQUIPMENT

Metal-Rimmed Gaskets. The metal rims bonded to the rubber keep these gaskets in their proper shape and position during assembly. **Acushnet Process Co., New Bedford, Mass.**

USE THESE TEAR-OUT POSTALS TO REQUEST ADDITIONAL INFORMATION DIRECT FROM THE MANUFACTURER

Aeronautical Engineering REVIEW

REQUEST FOR PRODUCT INFORMATION

An Official Publication
INSTITUTE OF THE AERONAUTICAL SCIENCES
(Aviation's Professional Engineering Society)
2 E. 64th St., New York 21, N.Y.

Please send information on the following item mentioned in the _____ Issue of AERONAUTICAL ENGINEERING REVIEW

_____

_____

_____

NAME..... POSITION.....

COMPANY.....

STREET.....

CITY & STATE.....

Aeronautical Engineering REVIEW

REQUEST FOR PRODUCT INFORMATION

An Official Publication
INSTITUTE OF THE AERONAUTICAL SCIENCES
(Aviation's Professional Engineering Society)
2 E. 64th St., New York 21, N.Y.

Please send information on the following item mentioned in the _____ Issue of AERONAUTICAL ENGINEERING REVIEW

_____

_____

_____

NAME..... POSITION.....

COMPANY.....

STREET.....

CITY & STATE.....

To:

PLACE STAMP HERE

Permanently Lubricated Locks & Latches. The lubricant is "cured" to each moving part, forming a bond that actually becomes part of the surface. **Adams-Rite Mfg. Co., 540 W. Chevy Chase Dr., Glendale 4, Calif.**

Standard Oilite Bronze Bearings. Twenty-six page descriptive catalog No. S-53. **Amplex Div., Chrysler Corp., Detroit 31, Mich.**

Fire and Overheat Detector. Saves 2 to 3 in. of working space because the sensing leg is built at right angles to the mounting flange. **Fenwal Inc., Ashland, Mass.**

Bearings Catalog. Contains information on complete line of standard Halfco bearings. **Halfco Div., Bearing Corp., 9632 Bellanca Ave., Los Angeles 45, Calif.**

Thread Repair Bulletin No. 654. Describes how stripped or worn threads can be repaired quickly and permanently by **Heli-Coil Corp., 1467 Shelter Rock Lane, Danbury, Conn.**

Hydraulic Valves to Specifications. Four-page facilities bulletin. **Hydraulic Research & Mfg. Co., 2835 N. Naomi St., Burbank, Calif.**

Quad Ring. Literature describes this four-lipped rubber seal that resists spiral twist. **Minnesota Rubber & Gasket Co., Dept. KP, 3630 Wooddale Ave., Minneapolis 16, Minn.**

Self-Locking Anchor Nut Assembly. This three-piece removable unit consists of a steel hex nut, a spring clip, and aluminum retainer base. **Nutt-Shel Co., Inc., 811 Airway, Dept. AER, Glendale 1, Calif.**

Stemco Type A Hermetically Sealed Thermostat. Employs a disc-type bimetal thermal element for quick make-and-break operation. **Stevens Mfg. Co., Inc., Mansfield, Ohio.**

Automatic Paralleling Control for A.C. Systems. On planes with alternator drive systems, the automatic paralleling control takes over the job formerly handled by the crew. **Sundstrand Machine Tool Co., Rockford, Ill.**

Illuminated Instrument & Control Panels. Brochure "D" describes method of obtaining maximum visibility both by day and night. **Universal Aviation Equipment Inc., 362 Fifth Ave., New York 1, N.Y.**

Flow Sensitive Pressure Regulator. Designed to prevent stalling of a fixed displacement hydraulic pump when the input torque is reduced below the value required to meet the setting of an ordinary fixed setting pressure relief valve. Brochure No. A-5226. **Vickers, Inc., 1400 Oakman Blvd., Detroit 32, Mich.**

DEPARTMENT OF TECHNOLOGY BUFFALO PUBLIC LIBRARY

ELECTRONIC & ELECTRICAL EQUIPMENT

To:

PLACE STAMP HERE

Model SF "Agastat" Time Delay Relay. This hermetically sealed unit is described in bulletin No. SR5. **AGA Div., Elastic Stop Nut Corp. of America, Elizabeth 3, N.J.**

Type F-12 Filter Assembly. For use with any signal generator that provides 90/150 cycles per sec. modulation for air-borne VHF glide slope or localizer receiver testing, to permit checking the accuracy of the modulation levels provided by the generator. **Aircraft Radio Corp., Boonton, N.J.**

Microwave Directional Coupler Design. Six-page technical bulletin No. T-2400. **Airtron, Inc., Linden, N.J.**

Power Supplies for Voltage Regulation. Eight-page descriptive bulletin. **Allied Engineering Div., Allied International Inc., Connecticut & Richards Aves., S. Norwalk, Conn.**

"Blue Ribbon" Connector. A quick-disconnect connector for electronic subassemblies where low insertion and withdrawal force is demanded. **American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.**

Heavy-Duty Mobile-Type Power Rectifier. Designed for aircraft engine starting and ground operation of bomb bay doors and gun turrets, as well as other plane components; also used for testing d.c. control circuits and battery charging. **American Rectifier Corp., 95 Lafayette St., New York 13, N.Y.**

Selective Communications System. Designed to relieve pilot of necessity to wear headphones constantly by permitting the ground station to attract his attention by means of a flashing light only when contact is required. **Bendix Radio Div., Baltimore 4, Md.**

TR Shutter Tube. BL-58 offers wave-guide shorting and TR tube action, with continuous crystal protection. **Bomac Laboratories, Inc., Salem Rd., Beverly, Mass.**

"Design Considerations of a Saturating Servomechanism." Sixteen-page bulletin No. R-13. **Cook Electric Co., 2700 Southport Ave., Chicago 14, Ill.**

Series "R" High-Current Terminal Block. Features interchangeability with other standard high-current blocks on the market. **Curtis Development & Mfg. Co., 3266 N. 33rd St., Milwaukee 16, Wis.**

1/400 Hp. Miniature Permanent-Magnet Motor. For application in small fans, blowers, and other similar lightweight-load applications. **Dalmotor Co., 1375 Clay St., Santa Clara, Calif.**

Industrial, Electrical, & Electronic Instruments Catalog No. 54. This 190-page buyers' guide covers all types of meters, controls, and test equipment. **Electro Tech Equipment Co., 308 Canal St., New York 13, N. Y.**

G-M-Type 52 Servomotor. This $1^1/_8$-in. diameter unit is used principally in 60-cycle and 400-cycle circuits. **G-M Laboratories, Inc., Dept. B, 4300 N. Knox Ave., Chicago 41, Ill.**

Hermetically Sealed Mercury Switch. Requires exceptionally low loading of the activating system. **Hamlin, Inc., Dept. A-2, 1316 Sherman Ave., Evanston, Ill.**

Hermetically Sealed "Stabelex" D Capacitors. Operating characteristics include a time constant in excess of 4,800 hours; for use where unusual low absorption, high insulation resistance, low power factor, etc., are required. Bulletin No. 1117A. **Industrial Condenser Corp., Dept A-2, 3243 N. California Ave., Chicago 18, Ill.**

Automatic Direction Finder Loop Corrector. Adjustable to provide correction in 5-, 10-, 15-, and 20-deg. increments. **Learcal Div., Lear, Inc., 11916 W. Pico Blvd., Los Angeles 64, Calif.**

High-Temperature D.C. Solenoid. Designed to operate continuously at coil temperatures from −85°F. to 500°F. **G. W. Lisk Co., Inc., 14 South St., Clifton Springs, N.Y.**

Tone-Coded Selective Signaling System. This equipment allows ground-to-air radio transmissions to preselected individual aircraft. **Motorola, Inc., Communications & Electronic Div., 4545 W. Augusta Blvd., Chicago, Ill.**

Narco Model UDI-1 Distance Measuring Equipment. Gives the pilot direct indication of his distance in miles from any VOR (Omni) station or ILS equipped with DME. **National Aeronautical Corp., Ambler, Pa.**

C-Band Air-Borne Weather Detection Radar. Will penetrate a minimum of 15 miles of 60-mm. per hour rainfall, using a transmitter power of 75 kw. **Radio Corp. of America, Engineering Products Dept., Camden, N.J.**

Miniaturized Servo-Amplifier. Eliminates the need for an external d.c. source. **Servomechanisms, Inc., Westbury Div., Post & Stewart Ave., Westbury, N.Y.**

Lightweight Thermal Delay Relays. For aeronautical applications where maintenance-free delay control of an electrical circuit is desired. **Sheldon Electric Co., Irvington 11, N.J.**

"Soreng" Standard Solenoids. Bulletin describes solenoids available from stock. **Soreng Products Corp., 9555 Soreng Ave., Schiller Pk., Ill.**

Vacuum Tube Voltmeter. Type A is designed for incorporation in complex production test equipment, as well as lightweight air-borne or portable electronic equipment. **Trio Laboratories, P.O Box 143, Wantagh, N.Y.**

Hermetic-Sealed Connectors. Designed for electronic apparatus where sealed units are used. **Viking Electric, 1061 Ingraham St., Los Angeles 17, Calif.**

PRODUCTION & MAINTENANCE EQUIPMENT

"Sonogen" Model 500 Ultrasonic-Power Generator. Designed to accelerate cleaning and degreasing of small parts and metal objects such as strip, wire, and tubing, as well as complex components. **Branson Instruments, Inc., 430 Fairfield Ave., Stamford, Conn.**

"Foam Fire Protection." Sixteen-page descriptive booklet. **National Foam System, Inc., West Chester, Pa.**

"Newage Actograp" Electric Pen. Engraves any marking on all metals through a built-in electric magnetic vibrating system. **Newage International, Inc., 235 E. 42nd St., New York, N.Y.**

14-In. Hydraulic Vertical Surface Grinder. Features more rigid design throughout and higher table speeds. **Pratt & Whitney Div., Niles-Bement-Pond Co., West Hartford 1, Conn.**

Heavy-Capacity Hoist. For lifting and moving engines and fabricated aircraft components, removing and installing propellers, and lifting tail surfaces of aircraft for inspection or maintenance. **Safway Steel Products, Inc., 6234 W. State St., Milwaukee 13, Wis.**

Model F80-I-G Torque Wrench. Has a 0- to 80-in.-gram range and is suited for applications requiring special torque testing fixtures. **P. A. Sturtevant Co., Addison, Ill.**

Orbital-Type Air Sander. For fast material removal. **Sundstrand Machine Tool Co., Pneumatic Div., Rockford, Ill.**

"JD" Hole Punching Units. These units are designed to punch mild steel up to $^1/_4$ in. thick. Bulletin JD. **Wales-Strippit Corp., North Tonawanda, N.Y.**

24-Volt-Operated "Tug-Bar." Designed primarily for use in handling cargoes aboard aircraft and in other locations where direct current is available. **Western Gear Works, P.O. Box 182, Lynwood, Calif.**

USE THESE TEAR-OUT POSTALS TO REQUEST ADDITIONAL INFORMATION DIRECT FROM THE MANUFACTURER

Aeronautical Engineering REVIEW

REQUEST FOR PRODUCT INFORMATION

An Official Publication INSTITUTE OF THE AERONAUTICAL SCIENCES (Aviation's Professional Engineering Society)

2 E. 64th St., New York 21, N.Y.

Please send information on the following item mentioned in the _____ Issue of AERONAUTICAL ENGINEERING REVIEW

NAME ..... POSITION .....

COMPANY .....

STREET .....

CITY & STATE .....

DEPARTMENT OF TECHNOLOGY BUFFALO PUBLIC LIBRARY

Aeronautical Engineering REVIEW

REQUEST FOR PRODUCT INFORMATION

An Official Publication INSTITUTE OF THE AERONAUTICAL SCIENCES (Aviation's Professional Engineering Society)

2 E. 64th St., New York 21, N.Y.

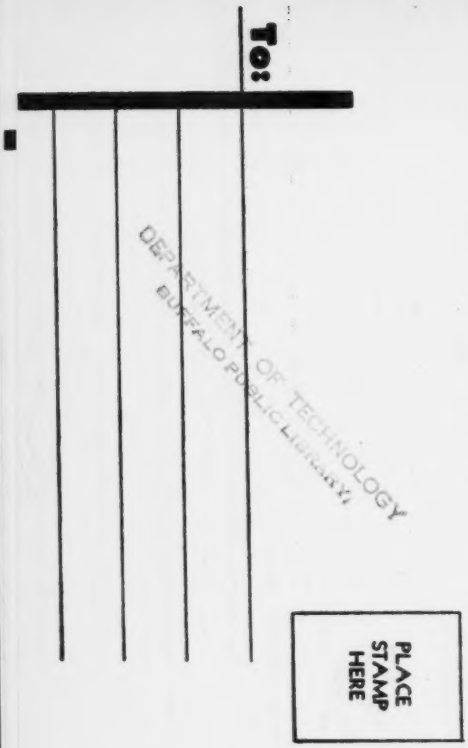
Please send information on the following item mentioned in the _____ Issue of AERONAUTICAL ENGINEERING REVIEW

NAME ..... POSITION .....

COMPANY .....

STREET .....

CITY & STATE .....



RESEARCH & TEST EQUIPMENT

Laboratory Apparatus & Pilot Plant Equipment. Sixteen-page descriptive bulletin No. 700. **Andrew Technical Service, 6972 N. Clark St., Chicago 26, Ill.**

Subminiature Analog Computer Component. This instrument, approximately 3 cu.in. in size, contains no moving parts and computes mathematical problems five times as fast as previous instruments. **Arma Corp., Roosevelt Field, Garden City, N.Y.**

Preset Counter. Provides high-speed counting for production processes that involve continuous unit flow or any movement that can be measured by an electrical device or mechanical pickup. **Atomic Instrument Co., 84 Mass. Ave., Cambridge 39, Mass.**

Creep Testing Machines. Descriptive 12-page bulletin No. 4208. **Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.**

Mobile Battery Power Supply & Selenium Rectifier Taper Charger. This unit incorporates the required facilities for both laboratory and production testing of electrical equipment in accordance with military specifications. **Bart-Messing Corp., 229 Main St., Belleville, N.J.**

Differential Pressure Potentiometer. Two-page technical data sheet No. 508. **Bourns Laboratories, Dept. NL, 6135 Magnolia Ave., Riverside, Calif.**

Pressure Gauge. Calibrates load and deflection conditions of helical compression springs. **W. C. Dillon & Co., Inc., P.O. Box 3008, 14620 Keswick St., Van Nuys, Calif.**

Servo-Accelerometer. Measures either linear or angular acceleration to four significant figures; laboratory applications include use as standards for checking and calibrating other transducers. Bulletin No. DSA-1. **Donner Scientific Co., 2829 Seventh St., Berkeley 10, Calif.**

Pressure Measuring Devices. For measurement in the fields of aerodynamics, hydrodynamics, engine research, pressure control, and ballistics. Technical brochure available. **Dynamic Instrument Co., Inc., 28 Carleton St., Cambridge 42, Mass.**

Electrical Resistance Temperature Detector. Model 221 N90A, designed for use with temperature recording, indicating, and control equipment where fast response is a primary requirement; the detector has an exponential time constant of 0.8 sec. or better in an agitated water bath. **Thomas A. Edison, Inc., West Orange, N.J.**

Recorder-Controller Instruments. Applications include recording and control of temperature, conductivity, strain, force, position, pressure, and telemetering. **Fielden Instrument Div., Robertshaw-Fulton Controls Co., 2920 N. 4th St., Philadelphia 33, Pa.**

Potentiometer-Type Pressure Transmitter. Model GPT is available in pressure ranges of 15 to 80 lbs. per sq.in. **Genisco, Inc., 2233 Federal Ave., Los Angeles 64, Calif.**

Miniaturized, Self-Contained Accelerometer. For recording acceleration phenomena in rockets, missiles, aircraft, etc. **Gulton Mfg. Corp., Metuchen, N.J.**

Pneumatic Signal Transmitter. Designed especially for use with the Hagan ring balance meter. Descriptive bulletin No. 9653-M. **Hagan Corp., Pittsburgh 30, Pa.**

Vacuum Indicator-Controller. Automatically maintains a vacuum system in any preset range between 1 and 1,000 microns of mercury. **Hastings Instrument Co., Hampton, Va.**

$1^1/_2$-In. DB Panel Meters. Engineering data sheet gives complete information. **International Instruments Inc., P.O. Box 2954, New Haven 15, Conn.**

Portable High-Pressure Pneumatic Test Stand. Air at pressures up to 3,500 lbs. per sq.in. is supplied by a 16- to 26-cu.ft. per min. (free air) 3-stage compressor to test complete high-pressure systems or their components. **Kahn & Co., 541 Windsor St., Hartford, Conn.**

48 to 144 Multipoint Logging System. Designed for testing and research applications where a record of all measurements is required. **Minneapolis-Honeywell Regulator Co., Industrial Div., Philadelphia, Pa.**

Variable "On Time" Timer. For timing operations such as product-like testing, energizing solenoids, feeding machines, etc. **Mount Sopris Instrument Corp., 1320 Pearl St., Boulder, Colo.**

Snap-Around Volt-Ammeter. Four-page descriptive Amprobe catalog No. 134. **Pyramid Instrument Corp., Lynbrook, N.Y.**

Universal Measuring D.C. Test Set. Described in bulletin *Electrical Measurements*, Jan., 1954, issue. **Sensitive Research Instrument Corp., Mt. Vernon, N.Y.**

Power Amplifier. Type 511A is a general-purpose laboratory power amplifier, useful as a test driving source for tachometers, synchros, small motors, choppers, and similar electromechanical devices. **Technology Instrument Corp., 531 Main St., Acton, Mass.**

Electronic Program Controllers. For automatic testing production and research testing programs. Descriptive bulletin No. 48. **Tinius Olsen Testing Machine Co., 1004 Easton Rd., Willow Grove, Pa.**

"Moisture Control In Compressed Air." Four-page descriptive brochure. **Van Products Co., 3768 W. 12th St., Erie 2, Pa.**

Miniature Pulsescope. Features instantaneous direct-reading d.c. calibration of either positive or negative going signals. **Waterman Products Co., 2445–63 Emerald St., Philadelphia 25, Pa.**